CHIROPRACTIC SPINOGRAPHY

THOMPSON

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ON

CHIROPRACTIC SPINOGRAPHY

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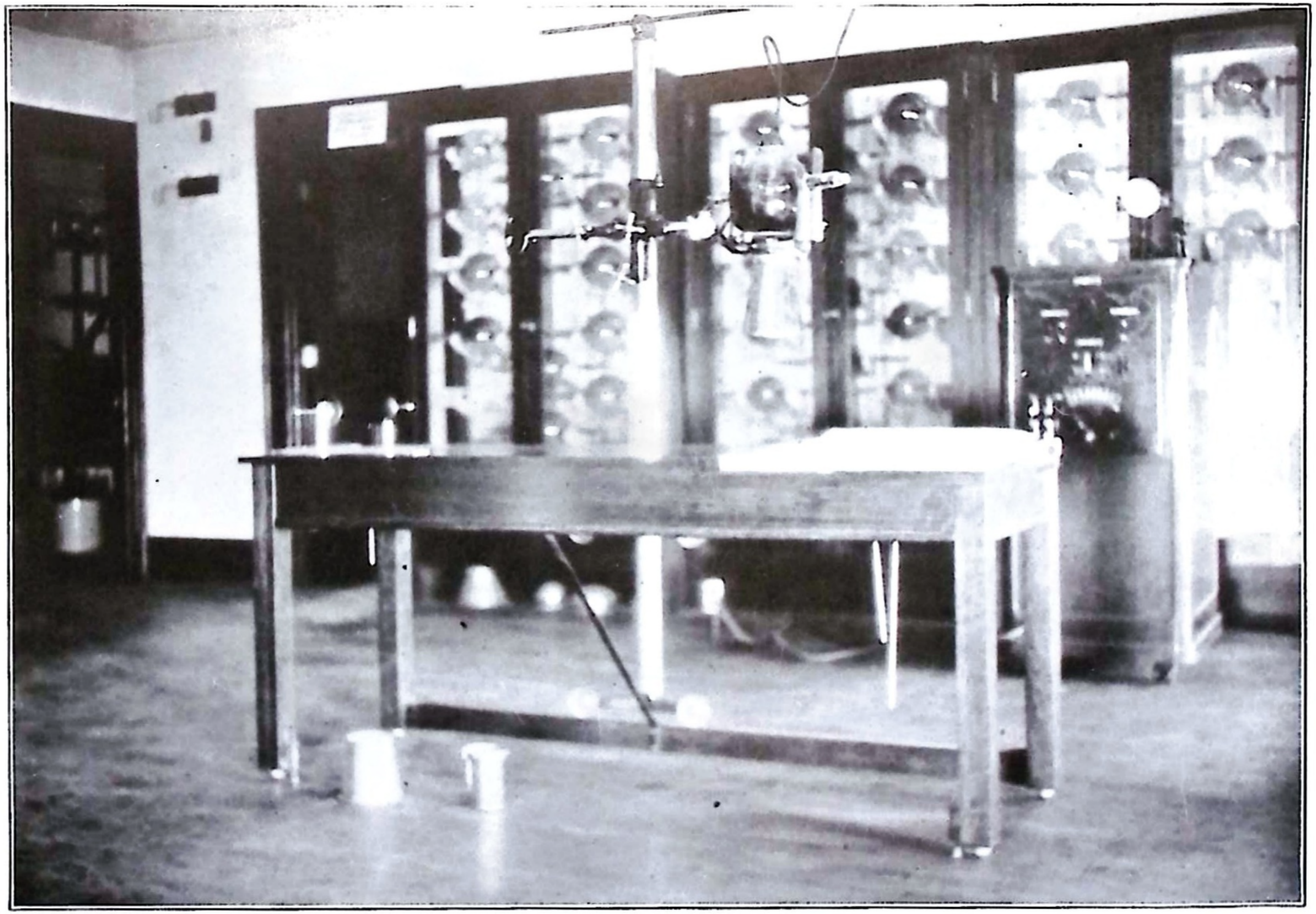


Figure 1—Showing One Corner of The P. S. C. Spinographic Laboratory with Table, Cases for X-Ray Tubes, and the Small X-Ray Machine.

PREFACE

Chiropractic is a progressive science and as is true of all progressive movements, it employs the progressive ideas which will add to its effectiveness. Early in its development Dr. Palmer realized the necessity of, in some manner, determining conditions of the spine which could not be sensed by the use of palpation. Certain conditions occasionally prevailed which baffled even the most skilled palpator and it is in these cases that the employment of the X-Ray, as a verifier of the Chiropractor's findings, should be utilized. Perhaps there is no one who has had the opportunity to become more proficient in the art of palpation than Dr. Palmer himself and yet he refers to the X-Ray operator many cases. This is merely mentioned to show the value of spinography even to the expert and proves conclusively the necessity of it to the practitioner who does not have these advantages.

With the realization of this fact in view, the science of Spinography has been developed and this book has been written, not to deal with the various phases of Roentgenology, but with that particular branch which applies to the study of the spinal segments and their juxtaposition.

At this time, I wish to acknowledge the valuable and kindly suggestions of Dr. B. J. Palmer, in preparing this work; to thank Mr. F. J. Farrelly for permission to use his valuable and instructive paper on the "Physical Properties of the X-Ray"; also to thank Mr. Wm F. Meyer for supplying cuts, and his assistance in preparing definitions. I personally wish to thank Mr. G. M. Ellis for the idea of preparing this work and for the many valuable hints he has given me along X-Ray lines. I am very grateful to my

friend, Dr. L. W. Healy, who has corrected and submitted the work on electrical terms, and to my valuable assistant, Mr. Clyde C. Hall, who has so ably prepared the article on Dark Room Work. I am indebted to my friends, Drs. Charles Green and Willard Danforth for their assistance in compiling and correcting this work. I also wish to thank Mr. George W. Brady for his many courtesies and valuable suggestions.

ERNEST A. THOMPSON.

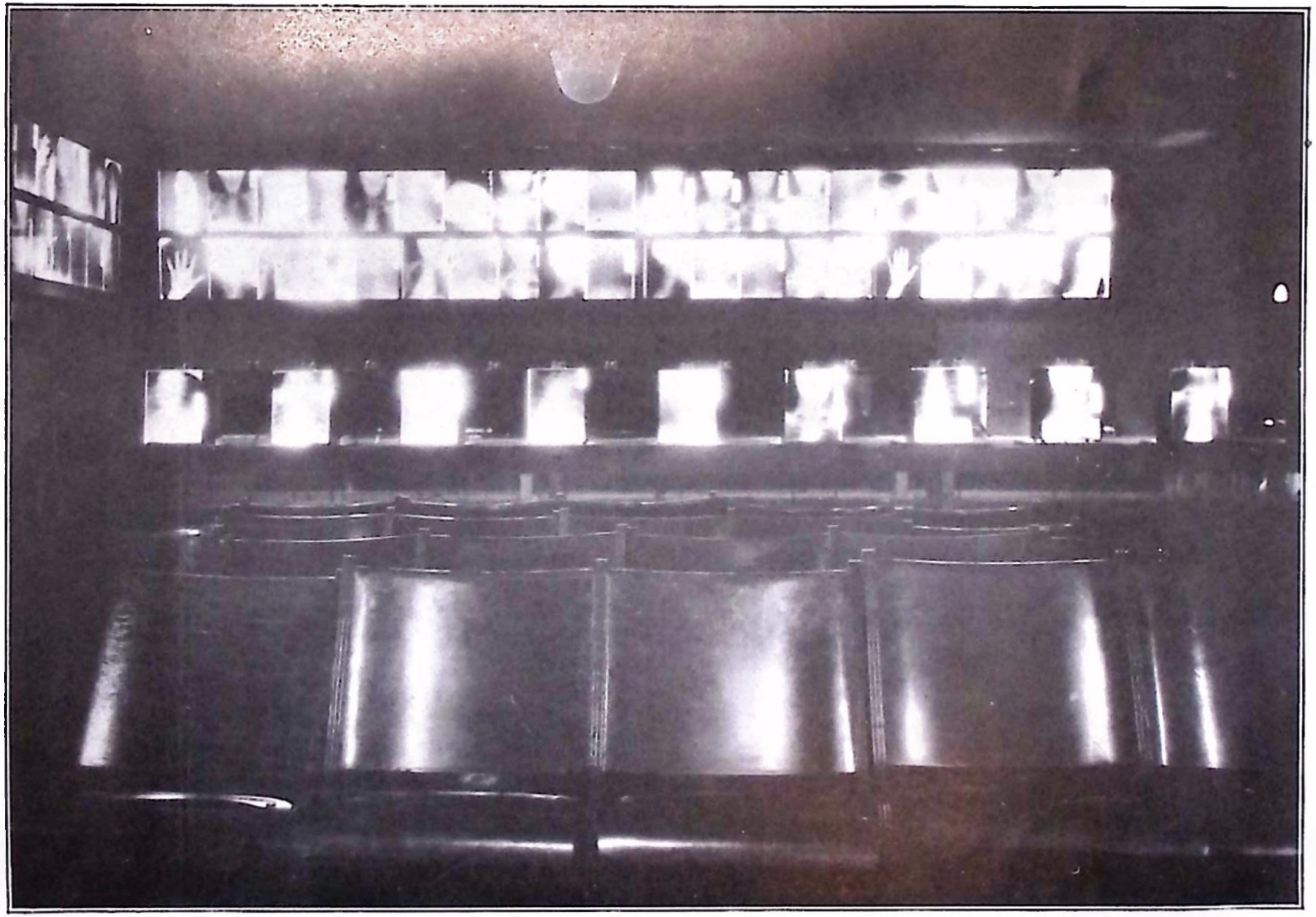


Figure 2—Another Corner of The P. S. C. Spinograph Laboratory with Display Cases Above and Reading Boxes Below, Which Are Used by the Students in the Study of Plate Reading.

INTRODUCTION OF SPINOGRAPHY

ITS ORIGIN, PURPOSE, FIELD OF LABOR AND WHY

As to the discovery of X-Ray work, I am not conversant except in a general way. As to mechanical details, I possibly know less.

History shows peculiar turns, at times. When I was young, our family lived next door to a large electrical plant where the city's "juice" was made. I used to make this my hang-out; always asking questions and gathering information. Little did I then think that some day I would use it in X-Ray work. At a later period, after going into business, I took up photography for a fad. Little did I then think that some day this would work into several angles of my future business, including the photographic end of X-Ray work. I also spent much time around printing plants. I now use all the information I then obtained.

The history of the X-Ray was a struggle of many downs and ups. In its experimental age, I watched the work with interest and let the other fellow have his grief; however, also, I made a yearly trip to Chicago to the Electrical Show and watched the progress of the X-Ray work, always hoping that some day a machine would be made which would and could penetrate the body to make pictures of spinal columns. Nowadays it seems impossible that once upon a time this could not be done. I would visit the factories which made X-Ray machines, telling them of my hopes and desires.

Finally, that machine appeared. I immediately ordered one shipped to the P. S. C. We fitted up a laboratory and began work. For two years we made as many plates as time and finances permitted, daily. We never made a charge. Were we not merely doing our share of the experimental work, even upon spines? At the end of two years we began to charge $1.00 a plate. It was five years before we charged $2.00 per plate. All this free and low rate work notwithstanding, the lowest priced plate in some X-Ray laboratories that could be purchased was $25.00 for even a wrist.

It was during these experimental years that we went thru the starvation scientific period. We developed the technique that is today known as P. S. C. Spinography; taught only here from then until now; started here, radiated from here and comes back to us tenfold with many lives saved.

We introduced the X-Ray into spine work back in 1910. We were the first people in the world to do so. Up until that period internal visual spine work was practically an unknown quantity. The living human spine was as the shores of Africa before Livingston or Stanley had set foot on it. Many was the time in our earlier years, that our spine plates were exhibited at many of the different "regular" medical conventions, without name and address, of course. Many were the compliments passed upon that work done in deeper tissues, especially of the spine.

The X-Ray was originally used by physicians, pathologists and diagnosticians, to ascertain the location and condition of pathology; the position of traumatic conditions; the location of foreign substances; and, experimentally, it

was being tried as a cure-all for diseases, more particularly cancers, etc.

The original Chiropractic purpose was not to use the X-Ray for therapeutic purposes, to ascertain normal or abnormal tissues, the character of a fracture or whether there was renal calculi or a bullet in the body. We had already settled how a cure occurred; we did not care much about pathological plates; we did not deal with fractures or dislocations and if there was a bullet or other foreign substance, then that was for a physician or surgeon, not a Chiropractor. We knew our place and proceeded to strengthen our position accordingly.

Chiropractic had long maintained, even at this early period, that a vertebral subluxation produced a pressure upon nerves which interfered with the normal and free transmission of mental impulses between the brain and its body; that this unequal state of balance between generation, transmission and expression produced disease. That the sunnum bonum of all life and death, health or disease issues pivoted around a study of the correct or incorrect position of vertebræ.

Therefore, the Chiropractor palpated the spine, found irregular bumps which we called "vertebral subluxations," being something short of a dislocation or fracture; we "adjusted" the subluxation, reduced its position to normal and the patient got well.

Physicians who ought to know, denied any of our realities. If it could be, they would "have found it long ago." Vertebral subluxations could not be without fracture or dislocation, in which event the patient would be dead.

When we saw the bump, he showed us bumps on knuckles—"does that prove the subluxation thereof?"

Under adjustment they moved, so did he work his joints—"does that prove the subluxation thereof?"

We heard them crack when adjusted—he pulled his fingers and they cracked—did that prove anything?

We said the patient felt them move; this he claimed was psychological—they just thot so.

All we offered him "was theory and art"; what we thot and what the patient thot; what we said we felt or saw, and what the patient said he felt in the back and with his disease. This he maintained did not prove any of our contentions. He offered scientific and laboratorical proofs why this could not be so. He could scientifically reason us out of our chiropractic house and home. We were, plainly speaking, "buffaloed."

Inasmuch as everything we said or did; what we went after or secured; our statements and logical facts; the patient's pains and reliefs, revolved about that vertebral subluxation, all of which could be scientifically denied. It was up to us to prove with the same degree of scientific proof that it did exist.

So, the advent of the X-Ray into Chiropractic was to prove that vertebral subluxations did actually exist and could be so proven with the aid of the X-Ray make this visible to the eye.

Physician after physician would stand aghast at the actual clinical changes taking place in case after case, as a result of vertebral adjustment; they would stand amazed at

the disappearance of pathology which they knew was positive; they had tested our cases before and after and thoroly satisfied that before they had to die and now they were well, but when it came to acknowledging that **an adjustment of a vertebral subluxation did it,** here they bucked and refused to credit it.

Once we had hurriedly perfected an early technique and began taking hundreds of plates, the evidence was before them, beyond all dispute. One by one they acknowledged the fact and then, **and not until,** was there a radical change in the attitude from ridicule to seriousness of our fundamental working principle and a taking stock in the philosophy which had to accompany the same to be consistent with the results delivered.

Whereas once medical books said a vertebral subluxation was imposible without fracture or dislocation; whereas other books said two teams of "Percheron horses pulling against themselves could not budge one vertebra from the other, in the recent state," now most every book acknowledges them as of common occurrence, in fact, some books go so far as to admit that most everybody has them. Medical dictionaries, recognized as standard, now include in them our common nomenclature of "subluxations," "adjustment," "Spinography," etc., most of them quoted from the writings of the author of this chapter in this book.

Having established this phase of our work, the X-Ray would have to go into the discard or, possibly, there was some more useful use of the same.

To prove the clinical hypothesis of a vertebral subluxation, we palpated with our fingers over the surface of the skin, found "a bump," established which direction it

was in, proceeded with our work. We succeeded in many cases, failed in others. Why? Perhaps the position that we thot we felt was not correct. Suppose we take a picture and see exactly how it was inside.

In proving the primary purpose, we found that in many cases what we thot existed under palpation, was not so.

Reasons:

Palpation could be in error.
Judgment could be false.
Spinous processes could be bent.
Exostosis could exist and fool us.
Process tips could be hypertrophied.

Acromegaly and other conditions could bewilder us.

This necessitated some form of scientific work which would let the Chiropractor's eye look into and see exactly what existed. We wanted to know the position of that vertebra exactly as did the surgeon want to know the location of the bullet before he probed.

Cabot studied, carefully, 1,000 cases and made actual comparisons of diagnosis in the living and proved them by autopsy on the dead. He diagnosed them from the best means at his command, upon the outside, what he thot was inside, named it, and prescribed accordingly.

He palpated, auscultated, used stethoscope, felt the pulse, looked at the tongue, examined faces, urine, etc.

On 1,000 case comparisons he stated they were wrong in diagnosis in as high as 85% in some cases, but wrong on 50% in the gross.

Why? Because he's trying, from the outside, to determine what's inside.

The Chiropractor took several thousand cases, made accurate and careful analyses of their vertebral subluxations and then compared them with the spinographic plates of exact facts of the living case, not waiting for an autopsy to be of benefit to the dead case.

As many thousands of spines as the author has palpated in 23 years; as varied as those spines have been; as accurate as he aims to make his work, we tell you candidly about 25% of our analyses do not tally with the facts the spinograph reveals to our eye.

He palpates, makes analyses, from the surface, what condition he thinks is more deeply embedded.

Dozens of points or combinations thereof might throw him entirely off, no matter how experienced.

We are thoroly convinced, from the comparison of over scores of thousands of spinographs that a percentage is bound to be wrong.

Why? Because we're trying, from the outside, to determine what's inside.

Cabot's diagnosis is as good as it can be; our analysis is as correct as we can make it; neither Cabot's nor our honorable intention can be questioned; we have done the best we can with the means at our command.

Is it possible to eliminate this percentage of errors, be it large or small?

Is there some way by which we can know rather than hypothecate?

Yes.

As a result—the scientific art of spinography. No longer need we rely on theory or art. Science proves.

It has been said "spinography" was but a newly coined word to express the ordinary X-Ray work on the spines, therefore, spine-ography. The word was especially coined by us as did Eastman coin "Kodak."

There are hundreds of X-Ray experts, but nowhere are they touching the characteristic P. S. C. spine work.

Any one can be taught to work an X-Ray machine in an hour or two. The manufacturer teaches the purchaser in two days.

It takes us exactly one month, six school days a week, to somewhat inculcate the principles of this work to a student; and, at that, all this instruction is Greek except to he who is first a chiropractor, knows Chiropractic and practices its work. Even in this time we can but lay the principles and teach the art, all of which must be practically applied to his practice after he leaves here for the field.

Today spinography is used to interpret spines which have not been palpated; to correct the interpretations made by palpation; to learn of the reasons why our palpation may have been at fault, in living people, that absolute readings may be determined beyond a shadow of doubt, upon which adjustments can be given with a perfect degree of assurance of being properly adjusted in which all hitherto elements of doubt are entirely obliterated.

Spinography does more than to read subluxations, it proves the existence, location and degree of exostoses, ankyloses, artificial, abnormal shapes and forms on any, all of which may prevent the early correction to normal position of the subluxation thus proving to the Chiropractor why his patient could not get well or giving him the information which will show him what to do, where and how to work, which will restore early health to the case that he would have otherwise failed upon and probably making a "mixer" in our ranks thus driving him quicker and more nearly to that bourne from which few chiropractic travelers rarely return.

Spinographs are not photographs. A photograph is a graphic recording of that which is superficial to the object being pictured. A spinograph is a graphic recording of that which is deeply imbedded in the object being spinographed.

To make a photograph, the surface lights and shadows must be thrown on the object. To make a spinograph the lights and shadows must be thrown thru the object.

In a photograph, that which is light and dark, was light and dark on the object when photographed. In a spinograph, the conditions are reversed; that which was solid will be light and that which was thin will be dark.

Spinographs, then, are but shadowgraphs. That which is solid, which intervenes between the light and the plate will leave a light shadow and vice-versa.

Reading spinographs, then, is but a study of shadows; high lights and middle tones.

Every human body has size, rotundity and depth. The

emulsion on your plate is a flat tissue thickness, yet it records the shadows made by that entire body regardless of thickness. Assume a body, sixteen inches thick from the anterior to the posterior and the region being spinographed is the spine. The tube is placed above the abdomen, the plate beneath. The X-Ray passes from the tube to the plate; the shadows and lights being recorded. The patient was 16" thick when placed on the table, but the graphic recordings are but a tissue. In reading this plate, we must differentiate the depth of the shadow, thus placing its position. If it were possible to place three copper pennies, one on umbilicus, one on stomach, other on spine of vertebra, each at a different level, I could tell which was on top, all because of the different degree of lights recorded.

Thus are the different positions of vertebræ determined. The centrum pedicles and spinous process tips are as flat as a tissue on the plate, yet, they were not so in the body.

Reading spinographs is an art or science, which should be cultivated, upon which too much experience cannot be given.

Your work, primarily divides into three more important divisions:

1st. Proper palpation.
2nd. Proper analysis.
3rd. Proper adjustment.

As the latter two depend on the former, it must be started right in all events.

Case No. 1.

You palpate the spine.

Make an analysis.
Secure a record.
Adjust your case.
He gets well.

Your palpation was correct or he couldn't get well.

Case No. 2.

You palpate the spine.
Make an analysis.
Secure a record.
Adjust your case.

Case gets worse, does not improve or improves extremely slow.

You must conclude that your palpation was not correct or in line with the facts which a well taken spinograph can readily prove.

To spinograph that case is to save failure with it.

You are poor, you are just starting, you can't afford a spinograph outfit.

Your case is poor, the distance is too great from you to us; what can you do?

You can't do. If you are poor, you can't buy; if your case is poor, he can't buy railroad fares.

If you are just starting and can't afford an outfit, and your case can't afford to come, send the case to some place where spinography has been properly studied, where this work is correctly done, where the price is within reach, where the tremendous overhead is assumed by others, where the work is so abundant that it is excellent and where

they can't afford to do otherwise than do for you that which you can't do for yourself.

Hundreds of Chiropractors have referred thousands of patients to us for spinographs during the past nine years.

Our average, at present, is between 150 to 200 Chiropractors per month sending cases for which we make on an average of 150 to 180 exposures weekly.

Our own faculty refer their doubtful cases to this department showing that we not only teach its use, but use it.

Invariably, the report returns to us of succeeding where before it was failure, cutting down length where before it lengthened, saving life and pain where before it would take it.

Success is based, Chiropractically, on results, first, last and all the time.

Can you afford to lose a single case, either in death, failure or non-delivery of results.

Hundreds of Chiropractors, from Coast to Coast, Canada to Old Mexico say "No." There is not a state in the Union, and but few countries but what have sent their cases to our laboratory.

You have a case, in Washington or Maine; Florida or California. They need a spinograph. Who pays the bill?

You desire that we hold consultation over the case, palpate the spine before and after spinographing and send you a reading—who pays the bill?

Perhaps the case is of such character that you ought to come with the case—in such event who pays the bill?

These are all accounts that must be paid by the patient, railroad fare, spinographs, consultation, hotel expenses for

themselves and the Chiropractor—should he need to come—are paid by the patient

Frequently, the Chiropractor will gather six or eight patients, his expenses being divided pro rata.

The spinograph means the difference between failure and success:

No results and results.
Guess and knowledge.
Doubt and positiveness.
Theory and fact.

We extend you, each and all, an invitation to visit our spinographical laboratory.

See the hundreds of plates on daily exhibit.
See the exposures made.
Study the plates and their value.
Then, send your doubtful patients and make a larger success of your profession.

We take a pleasure in writing this introduction to this able and excellent work on Spinographic Technique. Dr. E. A. Thompson has been with us more years than any other teacher on this subject. He has unquestionably seen more work, read more plates, taught more students than any other one man living, not excepting the author himself. It is because he is so eminently fitted for this peculiar line of work, that his work on this question becomes a paramount valuable addition to the world's scientific publications. Judge not this work by its size, but by the actual, definite working knowledge it contains.

Chiropractically yours,

B. J. PALMER,
President the P. S. C.

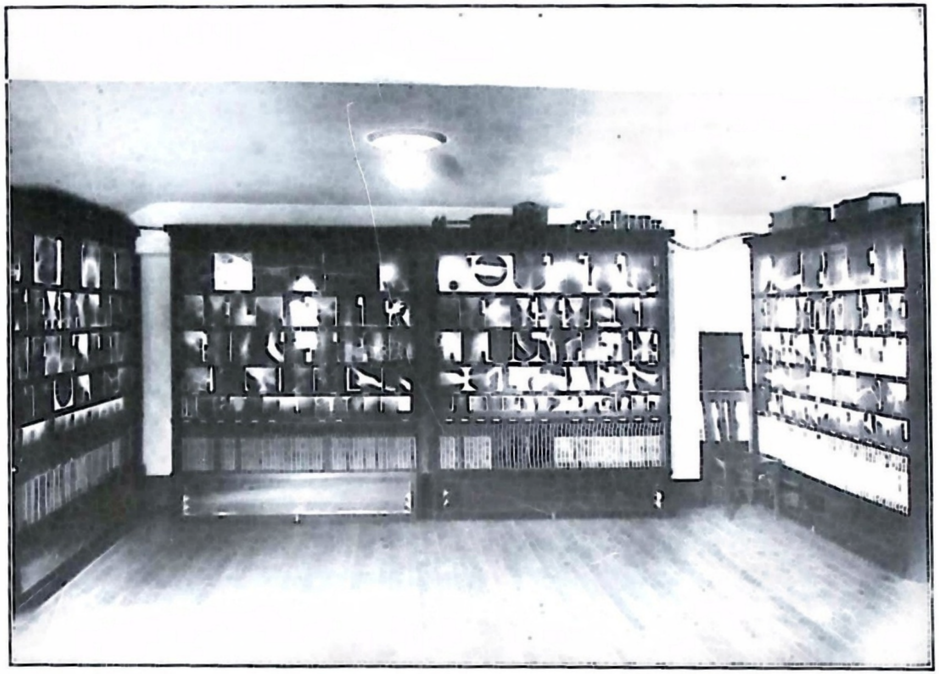


Figure 3—Another Corner of The P. S. C. Spinograph Laboratory
Showing Larger Display Cases

PART I

CHIROPRACTIC SPINOGRAPHY

The subject of Chiropractic Spinography deals with the taking of X-Ray pictures or radiographs of the spinal column showing all the vertebrae and their articulations with one another and being able to make a correct analysis of the plate or film after it is finished.

It has been the object of the author to make this book a practical one omitting some of the many theories that have been advanced so that any one using an X-Ray equipment for this particular branch of radiography may obtain a working knowledge thereof.

This branch of radiography is only one of the many branches that can be specialized with when working with the X-Rays, as there are many Roentgenologists who have made the taking of X-Ray pictures of certain parts of the body a specialty. To give an idea of the different kinds of X-Ray work and specialties, I have arranged the following as applied to each branch of radiography, as well as a few electrical terms.

DEFINITIONS

1. Photography—The science of taking pictures of the visible and the art or process of procuring pictures by the action of light on certain substances sensitized by various chemical processes.

2. Roentgenogram—An X-Ray shadow picture of the invisible parts of the body.

3. Radiograph—An X-Ray shadow picture of the invisible parts of the body.

4. Skiagraph—See radiograph.

5. Radiographer—One skilled in operating an X-Ray equipment.

6. Radiologist—One operating an X-Ray equipment.

7. Fluoroscopy—Science of X-Ray examination.

8. Roentgenology—The science of radiography (so named because it was first discovered by Prof. Roentgen).

9. Roentgenography—See Roentgenology.

10. Roentgenologist—One versed in Roentgenology.

11. Stereoscopic Radiography—The taking of two exposures of the same region with the source of rays moved the average distance between the pupils of the eyes or 2⅜ inches.

12. Spinography—Coined by Dr. Palmer, indicating the science of radiography as applied to the spine only.

13. X-Rays—So named because it is an unknown quantity.

14. Milliampere—The unit of electrical current flow in an X-Ray tube.

15. Ampere—The commercial unit of electrical current flow.

16. Volt—The commercial unit of electrical pressure causing current to flow.

17. Kilo Volt—One thousand volts.

18. X-Ray Tube—A glass bulb or globe exhausted to a high vacuum and provided with specific metallic electrodes within, designed to promote the electrical current flow in one direction when a high tension current is impressed upon the outside terminals of the electrodes, thus generating the X-Rays within.

19. Back-up Spark—When a current of high voltage is impressed upon the terminals of an X-Ray tube, the vacuum within will resist the passage of this current until the voltage or pressure is raised sufficiently to pass through the tube. The critical point where this occurs may be measured on a parallel spark gap and read off in inches and is called the back-up spark.

20. Transformer—For transforming a current of one voltage to another.

21. Converter—For changing direct to alternating current.

22. Motor Generator—For changing alternating current to direct current.

23. Direct Current—Flowing in one direction without periodic variation.

24. Alternating Current—Subject to periodic reversal called frequency.

25. Synchronous Motor—A motor, the rotary of which operates in step or synchronism with the alternating current used to excite it.

26. High Tension Rectifier—Usually in form of a disc with metallic segments for commuting the high tension alternating current of the step-up transformer into a pulsat-

ing uni-directional current desirable for exciting the X-Ray tube.

DISCOVERY OF X-RAYS

The discovery of X-Rays dates back to April, 1895, and was made by Professor Roentgen, the same year that Chiropractic was discovered. The first paper on the subject was read at the Wurzburg Physico-Medical Society on December 28, 1895. The discovery then really dates back to the Crookes Vacuum tube.

Although it is a fact that Roentgen was led to his discovery by Lenard and others, who were at the time experimenting with the Crookes Vacuum tube (in this connection we might state that Lenard as well as Stokes and Roentgen were led to a certain point by Crookes), nevertheless all former experimenters failed to see in their experimentation what Prof. Roentgen saw when he, as well as others, noted that the vacuum tube they were using had the power of causing fluorescence on a fluorescent screen. When Prof. Roentgen was asked, "What do you think about it?" he stated, "I will investigate." This he did and his investigation was so thorough that the fundamental principles of the X-Ray have never been changed. Altho there have been vast changes in the apparatus in the way of improvement in capacity, there has been no change in the fundamental rules laid down by Prof. Roentgen.

The actual discovery was accidental, like many other great discoveries in science. During the search for invisible light rays, Roentgen turned on a low pressure discharge tube, which was completely covered with dark paper that would exclude all ordinary light. A fluorescent screen was

lying on a table near by when the discharge tube was turned on and the screen became fluorescent. This experiment was followed by others in which Roentgen became convinced that they were new and penetrative rays which he promptly designated as X-Rays and the name still obtains.

In this simple way one of the most important discoveries was made in physics; one in which time has brought forth many improvements in the apparatus used to furnish current for the X-Rays, but no change in the laws which govern them.

Leonard missed priority over Roentgen by a very slight margin, as he had discovered the fact that the new light (X-Ray) would penetrate through an aluminum sheet and show light on the table below, but he had failed to follow up the lead and find out what the new ray really was able to do. It was Roentgen who established the facts in connection therewith.

PHYSICAL PROPERTIES OF THE X-RAY

Almost all of the literature published on X-Rays deals with the use of the same for producing radiographs, fluoroscopic examinations and treatments. Very little is published on their physical properties. The object of this paper is to give insight as to how X-Rays are produced and the passage of high voltage current through a vacuum.

In order to produce X-Rays it is necessary to employ current of high voltage and the poles are known as negative and positive, respectively.

The negative electricity plays the most important part in the production of X-Rays. Very little is known about

positive electricity, as it has never been isolated, held in suspension nor its path photographed like negative electricity —it appears to exist in name only.

Since the discovery of X-Rays and radium, the physicists have found that there is a mass of matter smaller than the atom and this is known as an electron or corpuscle; different writers using either name. In this paper the word electron will be used throughout.

An electron is the smallest mass of matter and is negative electricity. In fact, it is a solid mass moving through space and in a vacuum at different speeds. The size of an electron is about one thousand times smaller than an atom of hydrogen gas. All atoms, regardless of name or the different properties they possess, are composed of electrons.

An element—liquid, solid or gas—is a substance composed entirely of atoms of the same kind. The latest tables shows that there are about eighty elements and all these are composed of electrons.

The reason that elements possess different properties is because each atom contains a certain number of electrons. No two elements possess the same properties that are identical with each other or that will answer to the same set of tests. The property of the element lead is different from that of iron, and gold different from tin, yet they are all fundamentally made of the same material.

This is accounted for by the actual number of electrons that go to make each atom. For example, hydrogen is the lightest known gas, and the atom of this gas is one thousand times heavier than an electron; in other words, every hydrogen atom contains one thousand electrons.

If we could collect one thousand electrons, without regard from where they came, and could compel them to unite in one mass of a certain size, we could make an atom of hydrogen gas. The same applies to oxygen; this gas contains 16,000 electrons to an atom; nitrogen contains 14,000; mercury, 200,000. In order to estimate the number of electrons to an atom multiply the atomic weight of the atom by 1,000. As all atoms are of the same size, but of different weights, it is readily understood why one atom is heavier than another and why they possess different chemical and physical properties.

It has been stated that every electron is a solid mass of negative electricity, and that these electrons go to make an atom, so naturally we would think that a mass of electrons being negative would be forever repulsing each other and could not exist in the small space such as is in an atom.

Prof. J. J. Thomson has worked out a theory that the electrons in an atom arrange themselves at certain distances apart so that they will be in equilibrium under the attraction of the external shell of the atom and their own mutual repulsion. In order to illustrate this on a small scale, considering only a few electrons to an atom, say that there are only two electrons to an atom, they will arrange themselves like A and B in Figure 4. In this case they will be in equilibrium, if placed on opposite sides of the center of the atom and at a distance equal to half the radius.

If there are three electrons, A, B and C, they will be in equilibrium, if they form an equilateral triangle with its center at the center of the atom.

Four electrons will arrange themselves at the corners of a square, five will form a square with one in the center.

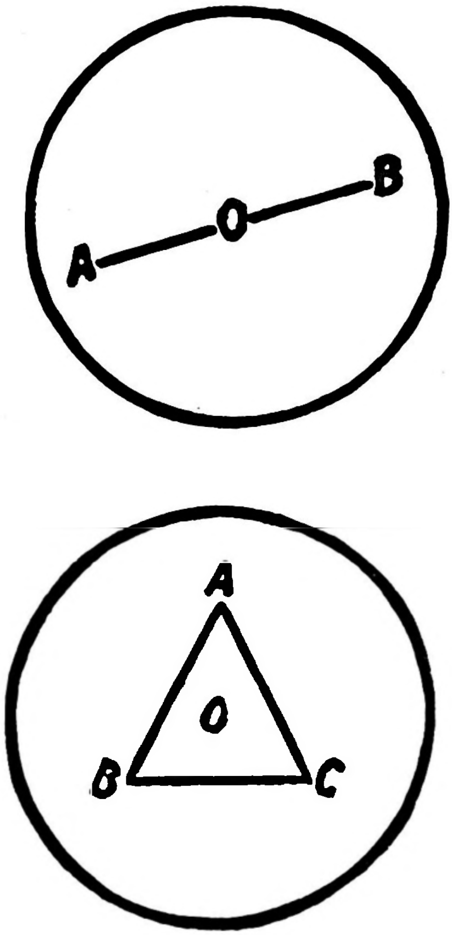


Fig. 4.

As the number of electrons to the atom increases, they will arrange themselves in a number of concentric rings, the outer ring containing the largest number and a decrease toward the center.

Electrons are not always bound up in the atom, but are found free in an atmosphere of glowing metals, incandescent carbon or gas flame; they are driven off metals when exposed to ultra-violet light, and around the discharge of any high voltage apparatus, or in air exposed to a discharge of X-Rays.

The cathode stream is entirely composed of electrons, as is the beta ray of radium.

As said before, no one knows what positive electricity is; it seems to exist in the form of particles the size of an atom, or, in other words, it is an atom that has lost one electron. It has never been weighed or held in suspension, nor its path photographed. It is known beyond doubt that negative electricity is contained in positive electricity, that the electrons are all inside of the atom and that the outer shell of the atom is positive, which balances the negative electricity or electrons within.

The foregoing paragraphs describe the nature of the electron in elements, and now we will describe the action of an electron in a vacuum.

The word "ion" will now be substituted for that of atom, as this is the proper term when referring to an atom in a vacuum discharge.

In an X-Ray tube, we have in addition to the electron and ion the neutral ion, which is neither negative nor positive. A neutral ion contains a fixed number of electrons,

but it does not remain long in this state when in a vacuum discharge. The electrons are held tight in the neutral ion until it has absorbed a certain amount of energy, then one of the electrons is liberated, the ion becoming positive.

To make this reaction clear, suppose an ion contains 100 electrons, it is then considered neutral. At a critical point it throws off one of these electrons and the ion then responds to a positive charge. The liberated electron roams around the tube, collides with neutral ions, imparting energy to each one and in time attaches itself to an ion and is absorbed. The ion now becomes neutral, and in its turn moves around the tube colliding with other ions, and electrons, and after a certain number of collisions it has absorbed enough energy to throw off one electron. It is on this principle that the current travels in an X-Ray tube.

The electric current must have something to carry it, just as copper wire carries the current from the mains to the coil or transformer. The high voltage current breaks down the insulating properties of the vacuum, ionizing the gas into ions and electrons which are the conductors of the current.

In order to produce a continuous flow of electricity in a tube, it is necessary to have an equal amount of ions and electrons; the ions make electrons and the electrons make ions. As long as the proportion of these two is equal, the current will continue to flow. If the rate of recombination exceeds the rate of production, any electrons originally present in the tube will tend to disappear and the gas will cease to conduct electricity, while if the rate of production exceeds the rate of recombination, the number of electrons will increase and the gas will become a better conductor.

The fluorescence in an X-Ray tube is due to the ion when the electron is liberated. The speed of the ion traveling in an X-Ray Tube ranges between 1,000 to 20,000 miles per second. The electron when in the cathode stream travels at the rate of 37,000 to 90,000 miles per second, depending on the degree of vacuum and voltage.

The current in an X-Ray tube flows from the anode to the cathode, carried first by the ions, which in turn produce electrons. The ions are first liberated from gas that collects around and in the anode. The liberated gases carry a positive charge and are ions. These ions are attracted to the cathode and compel it to give up a large number of electrons.

The ions leaving the anode travel in two directions to the cathode, about 10 per cent traveling in a straight line and 90 per cent traveling around the wall of the tube.

When the ions are liberated from the anode they have already given up their electrons. These freed electrons in turn impart energy to the neutral ions, which in turn give up more electrons. The free electrons in time attach themselves to the ions and combine. The ions are attracted to the cathode and the electrons to the anode.

The electrons that are given up at the cathode are whipped into a stream by the current, forming the cathode stream.

When the cathode stream is suddenly stopped, X-Rays are produced. In order to stop the cathode stream suddenly, it is necessary to have it strike an element of high atomic weight and melting point. If an element of low atomic weight is used as an anode, such as iron, the cathode

stream is not suddenly stopped on the surface, but it penetrates the element and a very small amount of X-Rays are generated and these rays are without any penetrative power.

On the other hand, if the anode is an element of high atomic weight and low melting point, it would be useless, as the tube would be quickly destroyed by vaporization of the metal. In an element of high atomic weight the atoms are closely packed, and the cathode stream can not penetrate, but is stopped at the surface and a large quantity of X-Ray is generated.

Tungsten makes a very good anode because the atomic weight and melting point are high. It is safe to estimate that the temperature at the tube's anode reaches between 7,000 and 8,000 degrees Fahrenheit.

The penetration of X-Rays is controlled by the speed of the cathode stream, and this in turn is controlled by the voltage employed and the degree of vacuum.

It is a well-known fact that deep penetrative rays can not be obtained from a low vacuum tube, even if the voltage is high. This is due to the fact that in a tube of low vacuum there is a large amount of gas present, thru which it is necessary for the stream to pass. This gas acts as a resistance to the passing of the stream, and tends to decrease the speed, consequently weak penetrating rays are generated.

If the vacuum in a tube is high, it means that there are very few molecules of gas present; that these do not retard the stream, and that when it strikes the anode it does so with a tremendous impact.

When the cathode stream strikes the anode, it sets up

ether waves or pulses of different lengths. These ether waves or X-Rays are generated at the anode surface and not after they pass out of the tube.

Some writers claim that X-Rays are particles somewhat like electrons, but this theory has few supporters. It can be stated in a few words that X-Rays are waves of ether set up when a cathode stream traveling at a tremendous speed is suddenly stopped. They travel in straight lines, cannot be bent by the strongest magnet and are neither negative nor positive.

Penetration can be explained as being the length of the generated ray, or ether wave. The wave length of X-Ray determines its penetrative power. X-Ray, like light, has a wave length and the shorter the wave length, the more penetrative it is.

The wave length of light has a fixed measurement, but with X-Ray it is different. The wave length of X-Ray varies from a very short wave length to a long one. The short wave length represents deeper penetration, and, naturally, the longer ones are less penetrative.

The production of X-Ray is not continuous the same as light, but is generated at irregular intervals.

The property of X-Ray to penetrate opaque substances is due to the fact that the waves are irregular and do not set up vibration in the surface struck.

Glass is transparent to light because it is not thrown into vibration by the light.

A thin sheet of metal is opaque to light, because the light waves, falling upon it, produce vibration within the metal.

The speed of X-Ray is the same as light; that is, it travels at the rate of 188,000 miles per second. The different wave lengths all travel at this speed.

In order to produce a picture of the head or hips when using a coil, the vacuum must be very high for the rays to penetrate to the dry plate. This condition is explained by the fact that the voltage from a coil is fairly uniform and it imparts a certain speed to the cathode stream when the vacuum is high.

A high vacuum means the absence of gas and, as before stated, consequently the stream attains a high speed and very high penetrative rays are generated.

Penetration and voltage are synonymous, but quantity of X-Rays is represented by milli-amperage. A ray can possess a certain penetrative power, but it might not be able to fog a dry plate unless backed up with quantity due to milli-amperage.

Induction coils can generate penetrative rays, but in a great many instances the ray so produced lacks quantity, therefore, it requires a longer time to take a picture compared to the time required when a transformer supplies the energy.

Deep penetrative rays can be produced in an X-Ray tube from a transformer, owing to the fact that the voltage can be varied from low to high. If the vacuum in a tube is low and high voltage is passed through it, the voltage overcomes the resistance of the gas and compels the cathode stream to travel at a high speed, producing rays of fairly high penetration. If a high voltage is passed into a tube in which the vacuum is high, the cathode stream reaches

its maximum speed and consequently for a short period a large quantity of highly penetrative rays is generated. If a low voltage is used to perform a certain function and the vacuum is low also, then to produce a certain amount of X-Ray time becomes the principal factor.

These varying conditions can be easily understood when we realize that at the time a tube is working at its maximum point, the speed of the cathode stream is about 90,000 miles per second, and is delivering at the same time penetration and quantity.

When a tube generates X-Rays below its maximum value, the cathode stream travels at a slower rate, producing a less quantity for the same time. When working under these conditions, the large amount of gas present not only impedes the cathode stream, but a large number of electrons from the stream are absorbed by the ions before reaching the anode. When the speed of the stream is rapid, all of the electrons reach the anode without combining with the ions.

It is sometimes difficult to understand why at one time a certain picture is taken in, say, one-half second, and again the same picture will require two or three seconds to produce the same results. This is due to the fact that for a given time quantity of X-Rays are generated and these rays attain their maximum speed; after the first picture has been taken, perhaps the vacuum has dropped and as a consequence, the speed of the cathode stream has slowed up and the X-Rays generated are of a shorter wave length and less penetrative, and in order to produce the same results time becomes the important factor.

It is on this principle that time is the important factor

in all picture making, irregardless of the type of apparatus, voltage or degree of vacuums.

Very frequently some Roentgenologists compare some of the X-Rays to the alpha and beta rays of radium; some even go further and say that these two rays are generated in an X-Ray tube.

Such statement is very misleading because X-Rays cannot be compared to them. The gamma ray of radium is like X-Ray.

The alpha rays of radium are very weak, and possess little or no penetrative power; they are absorbed by a sheet of ordinary writing paper or by four inches of air. They are positive atoms of electricity after they leave the mass of radium and then transmute into helium gas.

Physicians using radium for treatment generally filter the alpha rays out because they are dangerous to the skin.

The beta rays are particles or electrons thrown off from the radium at the rate of 100,000 to 150,000 miles per second and are more penetrating than the alpha rays, but not as great as the X-Rays. Beta rays are absolutely the same as the electron in the cathode stream and possess all the same physical properties except as to speed.

The gamma rays are analogous to X-Rays in all except penetration. The strongest X-Rays are stopped by a sheet of lead 3-16 inch thick, while gamma rays will pass through a solid piece six inches thick. The gamma rays are supposed to be waves of ether set up by the impact of beta rays passing through the atmosphere in the same way as X-Rays are when a cathode stream is suddenly stopped.

X-Rays cannot be deviated by a magnet, neither can the gamma ray; they both travel in straight lines and do not respond to either a negative nor a positive test.

Secondary radiations are a great source of trouble to all radiographers, and it is impossible to eliminate them, no matter what means are employed. When X-Rays strike a body it immediately becomes radioactive—that is, the body emits secondary rays or "S" rays, called after Sagnac, who was the first to detect them. Secondary radiations are not rays like X-Rays nor do they possess the same penetrative power; they are nothing else than electrons liberated from any body that the X-Rays strike.

Secondary rays are the same as the electrons in the cathode stream and the beta rays of radium. The penetration of secondary and the amount generated varies, depending upon the substance that the X-Rays strike. When X-Rays strike a sheet of aluminum the liberated secondary rays are more penetrative than if they strike a sheet of lead. When they strike the former, only a small amount of secondary rays are liberated, but they penetrate fairly deep, while with the latter they possess little or no penetrative power, but are liberated in a large quantity.

The reason that secondary rays cannot be entirely eliminated is because they are generated in the air when the X-Rays pass through, when the ray strikes the patient and also when they pass through the patient. They are also generated when they strike the envelope and the X-Ray plate.

It has been found that X-Rays can be reflected the same as ordinary light. This is done by passing a beam

of X-Rays through a crystal of zinc sulphide, the rays bending at right angles.

A later theory has been advanced by Rutherford in which he "regards an atom as built up of a minute nucleus of positive electricity" . . . surrounded by an inner cluster of negatively charged electrons which rotate round the nucleus, and an outer group of electrons which also rotate and are less rigidly attached. The outer electrons, by their number and arrangement, are responsible for the chemical and physical properties of the atom; the inner electrons have influence only on the phenomena of radioactivity. This explains why physical and chemical behavior do not go hand in hand with X-Ray and Gamma ray phenomena.

PROTECTION OF THE PATIENT

Protection of the patient and the operator is a very important part of X-Ray work, and everything written along these lines should be carefully considered by any one using the X-Rays. Patients can be burned with the X-Ray today as they were during the early stages of its development.

In those days the pioneers who were working with the X-Rays knew very little of the dangers connected with them, and many of them received X-Ray burns and some to the extent of losing their lives; thus they sacrificed themselves to develop this great and good work that you and I might profit thereby.

This is true of all great discoveries and undoubtedly will always be so. We only have to look back over the field of science and art to see the many who have given

up all they possessed that they might improve upon their work to help future generations.

Thru the experiences of these men the X-Ray world of today has taken heed and profited thereby. Today we know what to use and how to use it to protect ourselves and patients from any of the dangers produced by the X-Rays.

We do not hear of patients or operators getting burned with the X-Ray today as we did years ago, all because of the precautionary measures that have been applied to them. It is true that a few received X-Ray burns, but when you read or hear of it you can form your own conclusion, that it was carelessness on someone's part, and usually this carelessness is due to the operator, as he is supposed to know whether or not his equipment is in good working order.

There are not so many precautions, but what every operator could remember them. Read them carefully and always follow them and you will not be one of the careless few.

First, the operator should test the tube before making the exposure to see that it is in good working condition. By testing the tube we know whether or not it has proper penetration for the required exposure. It is true of all gas tubes that they may change in vacuum, become accidentally reduced or punctured, which should all be known before taking the picture, and this is found out by testing the tube first, which should be done before placing the patient upon the table. While making the exposure the operator should watch his tube and milli-ampere meter.

Do not expose a patient to more than 600 milli-ampere seconds at one time, as it is never necessary to use more than that for a Spinograph taken from the anterior to the posterior, if the proper technic is used. There would be danger of over-exposure if more than that were used.

Keep patient's hands away from the metal parts of the table so as to protect them from feeling the static electricity. When the hands loosely come in contact with any metal parts they will feel it. This may be stopped by placing their hands firmly against the cylinder. It is well to have a ground wire attached to the tube stand or table, having it connected with some piping that is grounded. This will take care of the static electricity. Should the patient suddenly feel the static current he may jump or move out of position, which would blur and spoil the plate. This static electricity produces no ill effects, but only frightens them. This we must try to avoid, as we must make the patient feel at ease.

X-Ray Burns. X-Ray burns may be produced by over-exposing the patient or by using a soft tube. A tube backing up at 3½ inches or less is not of sufficient degree to penetrate the heavier parts of the body rapidly, and as a result there is an accumulating effect from the very soft X-Rays and finally a burn. The rays passing thru the body do not burn unless it is an over-exposure. Those not passing thru, or secondary rays, are the ones that may result seriously to the patient.

No matter how high the degree of penetration, there is always a cetrain amount of secondary rays being given off, and it is the accumulating effect of these rays that finally produces the burn.

Aluminum filters are used between the tube and patient to decrease the effect of secondary rays; a thin piece of wood or leather will answer the same purpose.

Over-exposures and a soft tube will produce the following conditions: 1. Sterility. 2. X-Ray dermatitis, or erythema. 3. Decrease in white corpuscles. 4. Severe burn which acts similar to that of a cancer and a weakened, rundown condition, causing sloughing of tissue, etc.

PROTECTION OF THE OPERATOR

The operator must always bear in mind that he must protect himself as well as his patient as he is working with the X-Ray day after day and for this reason is more liable to the effects than the patient. He can protect himself by using the following precautionary methods, never allowing himself to become careless.

The author has worked with the X-Ray for a number of years without any ill effects whatever, all because he has used these precautionary measures and tried to be careful.

The operator doing much work should always work behind a lead screen or cabinet, as lead is opaque to the X-Rays and will stop all secondary rays. It is the secondary rays that are harmful to anyone continually exposed to them, and a lead screen or cabinet will stop them.

Almost all tube stands are equipped with a lead glass bowl, which acts as a receptacle for the tube, as well as being opaque to the X-Rays, helping to confine the secondary rays therein. But this is not enough if used without a lead screen, as it will not stop all the secondary rays

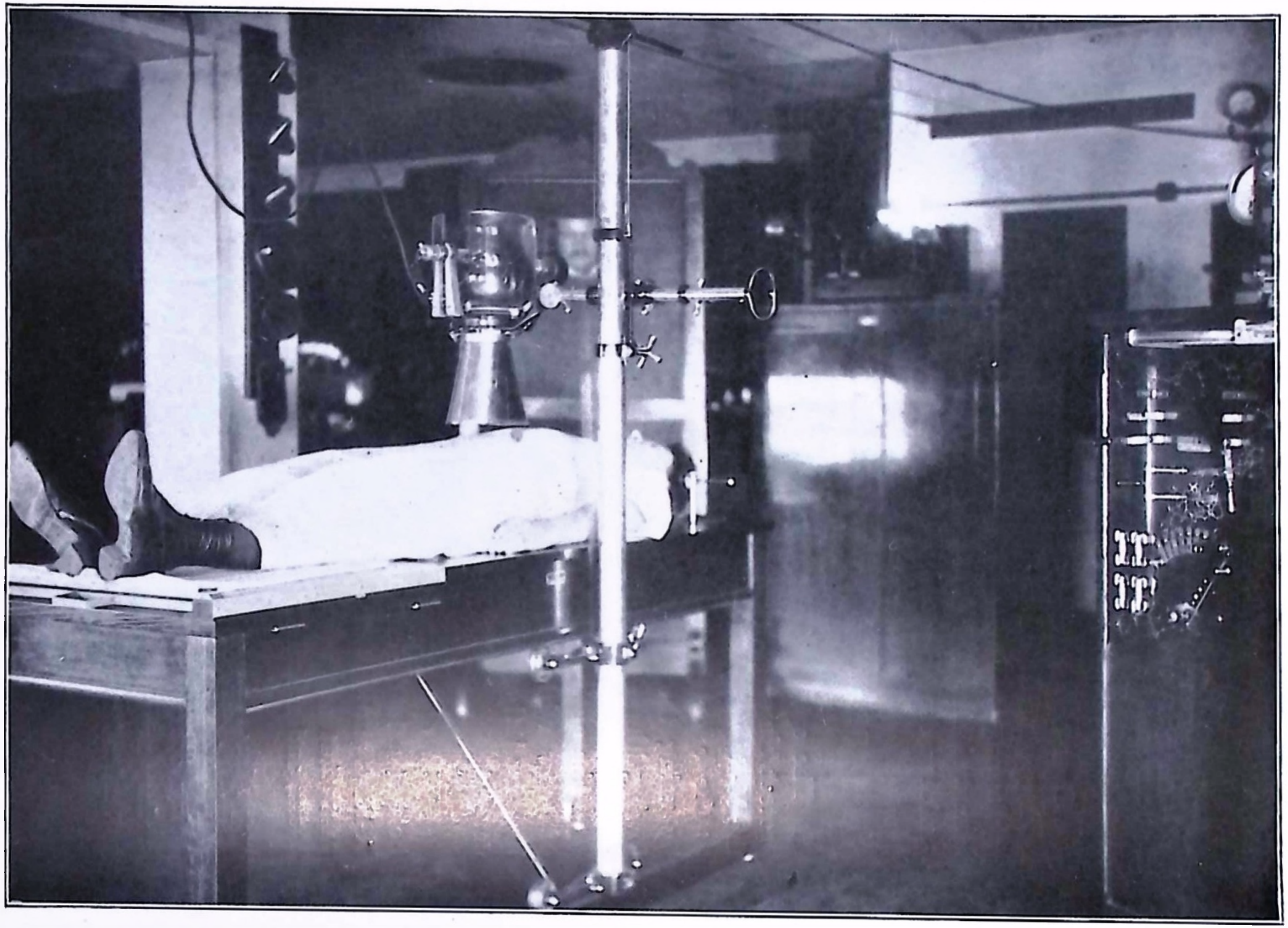


Figure 5—Another View of The P. S. C. Spinographic Laboratory Showing Proper Position of Patient upon the Table and Operator Standing Behind the Lead Screen, Ready for the Exposure

and some people are more susceptible to the effects of the X-Rays than others, more especially light-complexioned people.

Some operators have started using only a lead glass bowl for protection, to find sooner or later that they must make an addition to their equipment of a lead screen or cabinet. It is well to have a rubber mat to stand upon while using the machine, which helps to break any shock should the operator come in contact with any of the metal parts of the switchboard. It is safer to use one hand only in manipulating the switches.

The object of working behind a screen is to prevent the X-Rays from having an accumulative effect in the body. These X-Rays penetrate from 60 to 70 feet away from the tube and when a sufficient amount of them have accumulated, they may produce anemia or sterility, or have a weakening effect upon the body, while some operators are apparently not susceptible to them even after years of daily use.

PART II

PLATE READING FROM A CHIROPRACTIC STANDPOINT

Plate reading is a science in itself, and is one that requires a great deal of study. It differs very much from the work you are going through every day in palpating your cases, in the fact that you use your eyes, while in palpation you are developing the sense of touch so that you may determine laterality, inferiority and superiority by comparing one spinous process with those above and below. In plate reading we not only take into consideration the spinous processes, but also the transverse processes, the articulating processes, the upper and lower edges of the body of the vertebræ and the spaces found between the bodies of the vertebræ.

When you begin the study of plate reading do not attempt to see how fast you can read them, or how many you can read in an hour, as this is work that requires careful study and you must take your time.

In teaching this work I am preparing a foundation, and it is upon this foundation that you must build. Every day we have plates to read that present a new and interesting condition; something that must be carefully studied out. There are none of us who can claim to be thoroughly proficient in this work because of these new conditions presenting themselves for our study and analysis. That is why we must train our eyes for this work, and it will take a great deal of practice. Try, if possible, to learn these rules by heart, so that when you are reading plates it is

not necessary for you to stop and glance at the book, look up rule one, two or three, to make a listing. Get them firmly impressed in your mind; then you have them always there and ready to build upon. In your own practice you may have plates sent you from other practitioners for reading. You must be absolutely sure of your reading before you send your plates back to them. That is why I want to impress upon you the necessity of absolute care.

The first rule I have prepared for plate reading is the placing of the plate in the reading box. The emulsion side of the plate should be nearest the light and the glass side of the plate away from the light. I have made it a rule in taking spinographic plates to place a marker upon the right side of the plate. You will find that this marker is on every spinographic plate and should always be at your right hand when you are reading the plate; then you are sure of your direction. The reason for having this marker on the right side, and this side only, is that sometimes mistakes will be made in placing these plates in the envelopes. Then you will find upon reading that the emulsion will be away from the light, but the marker is still upon the right side, so this plate should be read with the emulsion side away from the light. In brief, the marker should always be to your right.

Rule No. 2 is to determine an imaginary median line of the spine and compare the spinograph shown upon the plate with that imaginary median line. The question arises, where do we find this median line? I refer you back to your freshman work, where you were taught the normal spine, the normal articulation of one vertebra with another, and it is here that you get a mental picture of a normal spine. If you have not this mental picture you could not

get your palpation as you are making comparisons every day; in every case you palpate, with the normal spine which you have in the mind's eye. Here we compare the spine shown upon the plate with normal, or imaginary median line, that we have in the mind's eye. It is your mental picture, then, which determines the median line.

Rule number three is to locate your first dorsal vertebra. To do this, we always look for the large transverse processes directly above the first pair of ribs, or to which the first pair of ribs are attached. This rule is given for the purpose of making a correct count of the vertebræ. If you have a plate showing the lower cervical and upper dorsal vertebræ, you begin by finding the first dorsal and either counting from there up, or from there down.

Sometimes you will find large transverse processes upon the seventh cervical vertebra; do not mistake these for the transverse processes of the first dorsal, as these you will always find above the first pair of ribs. You will note that the first pair of ribs does not extend out very far from the spine, as they curve around the clavicle. You will notice that the transverse processes of the first dorsal vertebra are usually larger than any of the rest in the spine.

Rule number four. To determine laterality of the dorsal or lumbar vertebræ: In determining laterality we not only take in the spinous processes, but we must also take every part of the vertebra into consideration. In palpation you compare the spinous processes; the bodies of the vertebra are too deep for you to palpate. In spinography you not only take the spinous processes, but you take the body of the vertebra itself, the transverse processes, articulating processes, the laminæ and the spaces found

between the bodies; all of these must be taken into consideration when making a listing. The first part of the rule in determining laterality is to compare the spinous processes with the ones above and below. After making this comparison with the vertebra in question suppose we say that we have found the spinous process to the right of the ones above and below it; our next step, then, is to measure the distance from the center of the spinous process to each edge of the body of the vertebra, and we find that the distance is greater from the center of the spinous to the left edge of the body, and it is nearer to the right edge of the body, proving, therefore, that the spinous process is subluxated to the right.

In finding the center of the spinous process we do not take the tip of the process as we do in palpation, but always look for the center of the lamina, which is the center of ossification for the spinous process. After finding this center we then make our measurements from one edge of the body to the other. In finding the outer edges of the body of the vertebra we look for the heavier white line, or the line which is slightly concave. Be very careful not to mistake the lower edge of the transverse processes for the edge of the body, as this shadow is always a little lighter in shade. After determining the laterality we take the tip of the spinous process into consideration to determine whether or not it is a bent spinous process. This, because, it is from this rule (measuring the distance from the center to each edge of the body) that we can determine a bent spinous process. First, we find the center of the spinous process; then measure the distance to each edge of the body, and make our listing of the laterality. If we find the center of the spinous process nearer the right edge

of the body and farther away from the left edge of the body, but the tip of that same spinous process is nearer the left edge of the body and farther away from the right you would list it as a right subluxation with a bent spinous process to the left. It is well to remember that in the middle and lower dorsal vertebræ the spinous processes overlap the bodies below and sometimes in the lumbar region as well, so you must be careful in finding the spinous process of the vertebra in question in this region.

Rule number five takes up rotatory scoliosis. A rotatory scoliosis is usually a hard condition for the student to comprehend. To determine whether or not we have a rotatory scoliosis we compare the scoliosis with our imaginary median line, and then measure the distance from the center of the spinous process to each edge of the body the same as in determining laterality. It takes two or more vertebræ to produce a rotation, or a rotatory scoliosis. When we speak of a rotatory scoliosis we mean there is a curvature produced by the bodies of the vertebræ being rotated; even though we find that the spinous processes are to the left of our imaginary median line, but still the spinous processes are nearer the right edge of the body of the vertebra, we would list it as being a right subluxation, because the spinous process is to the right of the median line of the vertebra itself.

You will also find that the left articulating processes in a rotation of this kind show much larger and plainer than the right articulating process, due to the fact that the left side is rotated nearer the plate.

Our listing in a case of this kind would be spinous processes to the right, bodies rotated to the left, or a left rotatory scoliosis.

To differentiate between a lateral scoliosis and a rotatory scoliosis, you will find that in the former the bodies of the vertebræ, as well as the spinous processes, are all to the left or right, as the case may be, of the median line of the spine. In the latter the spinous processes are to the right or left, as the case may be, of the median line of the vertebræ themselves, while the bodies of the vertebræ are rotated either left or right, but in the opposite direction. The spinous processes, however, would be to the right of the median line of the body of the vertebra in a left rotation and to the left in a right rotation.

Rule number six. To determine superiority and inferiority: We first draw a line by using a straight edge from the tip of one transverse process to the tip of the opposite transverse process of the vertebra in question. This is in order to determine whether the left or right transverse process is higher or lower on the side of the laterality. Next we place the straight edge along the upper and lower edges of the body of the vertebra to determine whether or not the body is tipped in the same direction that we have found the transverse processes. We then consider the articulating processes in the same manner, and if we have found that they conform to the tilting of the transverse processes we know that we have a subluxation either superior or inferior, and not a bent transverse process, as you will find bent transverse processes the same as bent spinous processes. After determining whether or not we have inferior or superiority, we add our findings to the laterality which we assume has been listed.

Rule number seven deals with laterality in the cervical region. In the cervical region, with the exception of the atlas, our laterality is determined first by finding the cen-

ter of the spinous process and comparing this center with the center of the one above and the center of the one below it.

As you know, the spinous processes in the cervical region, with the exception of the atlas, are bifurcated and our center is always found by finding the center of this bifurcation. We then measure the distance from this center to the outer edge of the body of the vertebra in question the same as you do in the dorsal and lumbar regions. The edge of the bodies in the cervical region is found by looking for the articulating processes, and you will find that the edge of the body is directly below them. You will also find some of the prongs of these bifurcations longer than others, but disregard this when reading the plate. Find the center and work from that. The superiority and inferiority in this region is determined in the same manner as in either the dorsal or lumbar regions.

Rule number eight deals with the atlas. The atlas being the most difficult one of the vertebræ to list, there are several rules that must be closely followed. First, when the exposure is taken of this region you must be very careful in placing the patient's head. Make sure that the head is lying perfectly straight and is not tipped either right or left, or up or down; the head must be level in order to make an accurate comparison with the surrounding structures. Second, we must always consider subluxations of the axis before attempting a listing of the atlas, as a tipped axis may, or will, mislead us if we fail to consider it first. Third, have a picture in mind of the normal articulation between the occiput, atlas and axis.

To determine laterality of the atlas after applying the

above rules, our first step will be to compare the outer edges of the lateral masses with the outer edges of the axis to find whether or not the lateral masses are to the right or left of the outer edges of the axis. After making this comparison we next consider the spaces found between the inner edges of the lateral masses and the outer edge of the odontoid process. Next we consider the distance from the outer border of the lateral masses of the atlas to the descending rami of the jaw. Also observe the distance from the tip of the transverse processes to the rami of the jaw. Do not attempt to list an atlas by any one part of this rule, as they all must be used collectively. To determine superiority and inferiority of the atlas, observe the space found between the articulating surfaces of the axis and the lateral masses of the atlas; also use a straight edge from one lateral mass to the other and from one transverse process to the other, as in some cases you will find the atlas and axis both subluxated, and these spaces will not change. By using a straight edge from one lateral mass to the other, as well as the transverse processes, we are able to determine whether or not the transverse process is bent, as will sometimes be the case. We must also consider the horizontal plane of the atlas with the vertical plane of the occiput and the median line of the spine. Example: If we find the atlas is subluxated to the right, the right lateral mass will be slightly to the right of the right, upper and outer edge of the axis. The space between the right lateral mass and the odontoid process will be greater than the space on the left of the odontoid process. If the rami of the jaw appear to be the same distance, or width, upon measurement, we will find that the right lateral mass will be nearer the rami of the jaw on this side. If you should find that these rami vary in width,

do not use them to determine any laterality, as it indicates that the jaw was tipped a little to the right or left when the plate was taken.

If the atlas is superior on the right side you will find upon using your straight edge that this right lateral mass is superior to the left lateral mass, and the space between the atlas and axis will be greater than the space on the opposite side. We will also find that the right transverse process will be higher than the left transverse process. Our listing, then, for the atlas would be, right and superior. The posteriority of the atlas must be determined either by palpation or by taking a lateral view of the cervical region. Views of this type also reveal inferiority and superiority, posteriority and anteriority. If we find that the spinous processes are tilted downward, or inferior, you will find the body of the vertebra tilted to the superior or inferior. This view will also show a dislocation, fracture, exostosis and ankylosis much better and clearer than an anterior to posterior view.

Rule number nine deals with subluxations of the ilii. To determine subluxations of the ilii, note the articulation of the same with the sacrum. If we find the ilium superior to its articulation with the sacrum, list it accordingly. In the majority of cases you will find that the pelvis is tipped higher on one side than upon the other, while the articulation remains normal. This tipping would indicate that it is adaptative to a scoliosis or rotation some place in the spine, or to a condition where one limb is found to be shorter than the other. Subluxations of the ilii, superior and inferior, are very rare, but you will find them subluxated posteriorily, which is determined by palpation.

Rule number ten deals with the reading of the coccyx.

To determine subluxations of the coccyx we must have a plate that covers the pelvis so that we may see the articulations of the symphysis pubes, noting whether or not the coccyx is to the right or left of the symphysis pubes or median line.

Rule number eleven. Always be very careful when reading plates that you do not fail to observe any abnormal conditions other than just the subluxations, as you may find exostoses, ankyloses, fractures or tubercular conditions, lateral curvatures and rotations.

Rule number twelve. In listing the cervical, dorsal or lumbar vertebræ, the student or practitioner is admonished against trying to list a subluxation by using just a part of the above rules, as they all must be taken into consideration in order to make a correct listing. Remember that anterior-posterior views only show laterality, superiority and inferiority. The posteriority is determnied from palpation unless you have a lateral view of the spine.

RULES FOR PLATE READING

1. Place the plate in the reading box with the emulsion side nearest the light and have the plate marker on the upper right-hand side, as this marker is always placed upon the right side of a spinographic plate.

2. Determine an imaginary median line of the normal spine and compare that with the abnormal spine pictured upon the plate.

3. To determine the first dorsal, look for the large transverse processes to which the first pair of ribs are attached. This gives you a landmark whereby you may obtain a correct count of the vertebræ.

4. To determine laterality of the dorsal or lumbar vertebræ we must take into consideration every part of the vertebra, viz. the following: First, compare the spinous processes with the ones above and below; to prove whether it is lateral, measure the distance from the center of the spinous process out to each edge of the body of the vertebra. In finding the center of the spinous process, seek the highest point of the laminæ, where they meet to form the spinous process.

It is from this rule that a bent spinous process may be determined. If we find that the center of the spinous process is nearer the left edge of the body, with the tip of the same spinous process nearer the right edge of the body, we would have a left subluxation, with a bent spinous process to the right and vice versa.

5. To determine a rotatory scoliosis, we first measure the distance from the center of the spinous process to each edge of the body of the vertebra, as in the above rule. If we find that the spinous process is much nearer the right edge of the body than the left, it would then be determined that we have a left rotation of the vertebra or vice versa. We always find that a rotation takes in two or more vertebræ, which fact produces the scoliosis. Even though we find that the spinous process is to the left of our imaginary median line, but still the spinous process is nearer the right edge of the vertebra, we would list it as being right. You will also find that the left articulating process in a condition of this kind will always show much larger and plainer than the right articulating process, due to the fact that the left side is rotated nearer the plate. To differentiate between a lateral scoliosis and a rotary scoliosis, we will find that the bodies of the vertebræ, as well as the

spinous processes, are all to the left, or right, as the case may be, of the median line of the spine, while in the rotatory scoliosis we will find the bodies rotated left, or right, as the case may be, forming a curvature, but the spinous processes would be to the right in a left rotation and to the left in a right rotation.

6. To determine superiority or inferiority, observe whether or not the transverse processes are level by using a straight edge from one to the other. Also observe the angle of the upper and lower edge of the bodies to see if they correspond with the angle formed by the transverse processes. Also use the articulating processes in the same manner, as this will prove that the subluxation is either superior or inferior and not a bent transverse process. We next consider the spaces between the vertebræ, both above and below. We cannot use any one point of this rule separately to determine superiority or inferiority. Use each point given, adding your findings to the laterality, which we assume has been determined.

7. In the cervical region, with the exception of the atlas, determine the laterality by comparing the center of the bifurcation with the one above and below, measuring the distance from the center to each edge of the body, as given in the rule above. Superiority and inferiority in this region is found in the same manner as in Rule 6.

8. The atlas being the most difficult to list, there are several points that must be closely followed.

A. In taking an exposure of the atlas, the head must be perfectly straight in order to make an accurate comparison with the surrounding structures.

B. Subluxations of the axis must be taken into consideration before listing an atlas.

C. Have a picture in mind of the normal articulations between the occiput, atlas and axis.

To determine laterality of the atlas, after applying the above rules, compare the outer edge of the lateral mass with the outer edge of the axis to find whether or not the lateral masses are right or left of the axis. Also compare the spaces between the inner edge of the lateral masses and the odontoid process. Also measure the distance from the outer border of the lateral masses of the atlas to the descending rami of the jaw and observe the transverse processes to determine whether they are to the right or left of the rami of the jaw.

To determine superiority and inferiority of the atlas, observe the space between the articulating processes of the axis and the lateral masses of the atlas. Also use a straight edge from one lateral mass to the other and from one transverse process to the other, as in some cases in which the atlas and axis are both subluxated, there will be no difference in the space between the articulating surfaces of the atlas and axis. Also compare the horizontal plane of the atlas with the vertical plane of the occiput and the median line of the spine.

Example: If we find that the atlas is subluxated to the right, the lateral mass on the right side will be slightly to the right of the edge of the axis. The space between the lateral mass and the odontoid process on the right side will be greater than the space on the left side. The right lateral mass will also be nearer the descending rami of the jaw. If tipped superior on the right side, the space between the

atlas and axis will be greater than that on the opposite side. We will also find the right lateral mass and transverse process higher than on the left. We will then list the atlas as being right and superior.

Posteriority is determined by palpation or by taking a lateral view of the cervical region. This view also reveals inferiority and superiority by judging the distance between the spinous process and the angle formed by the body and the spinous process.

Example: If we find the spinous process tipped downward and much closer to the one below than the one above, you will find that the body of the vertebra will be tipped upward, indicating an inferior subluxation and vice versa. This view will also show a dislocation, fracture, exostosis and ankylosis much better and clearer than an anterior to posterior view.

9. To determine a subluxation of the ilii, note the articulation of the same with the sacrum; if we find the ilium superior to its articulation with the sacrum, list it accordingly; but if we find that the pelvis is tipped higher on one side than the other and the articulation normal, it would indicate that the tipping is adaptative to a curvature of the spine, or a condition where one limb is shorter than the other.

10. To determine subluxations of the coccyx, note whether it is to be right or left of the median line.

11. Always be on the lookout for other abnormal conditions, as you may find exostoses, ankyloses, curvatures, fractures, caries or tubercular conditions, etc.

12. In listing the cervical, dorsal or lumbar vertebræ,

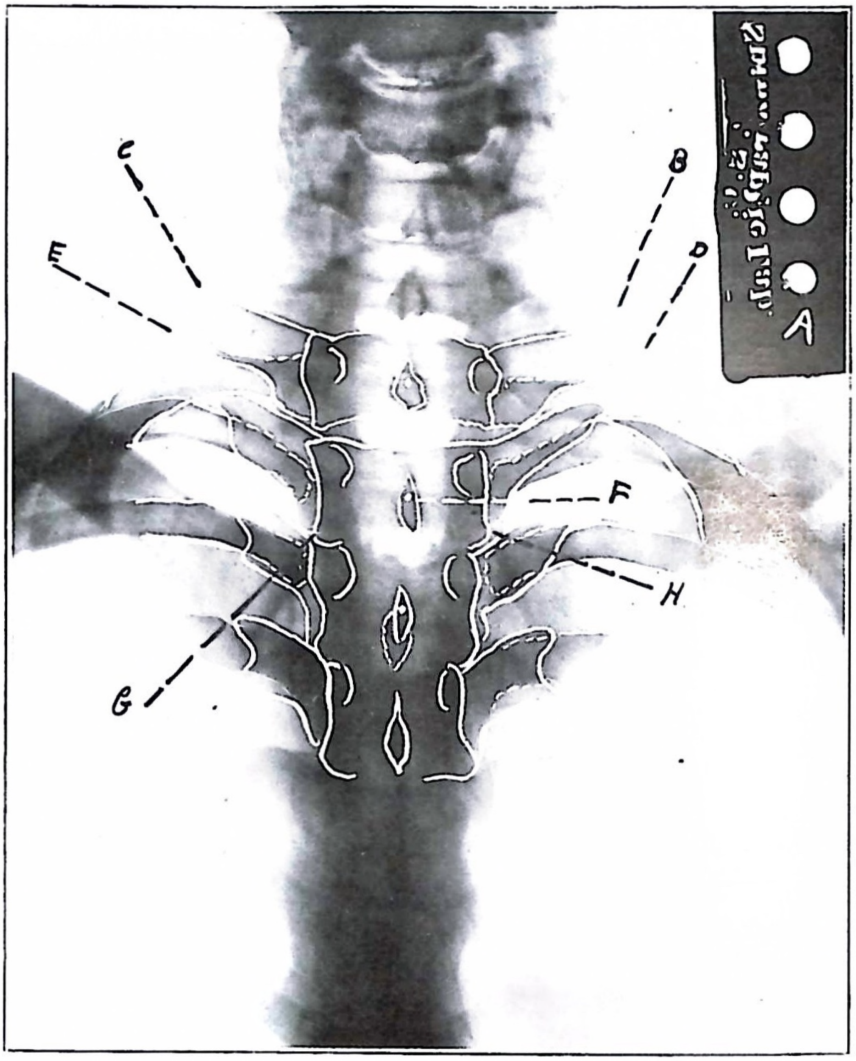


Fig. 6.

the student or practitioner is admonished against trying to list a subluxation by using only a part of the above rules, as they all must be taken into consideration in order to make the correct listing.

RULES AND READING OF FIG. No. 6

Rule No. 1.

Letter A shows position of number plate when placed properly in reading box.

Rule No. 2.

The imaginary median line in reality is the picture you have in mind of a normal spine. With all spinous processes directly in line with one another.

Rule No. 3.

Letters B and C represent the transverse processes of the first dorsal vertebræ, which are directly above letters D and E, which represents the first pair of ribs.

Rule No. 4.

Letter F represents center of spinous process of 2nd dorsal vertebra, G and H representing the outer edges of the body.

To determine the laterality measure from center of spinous process F to edge of body G and then make the same measurement between F and H, the side having the lesser distance, which is H in this case, shows it to be a Right subluxation.

Our spinographic listing would be as follows:
2nd dorsal R.

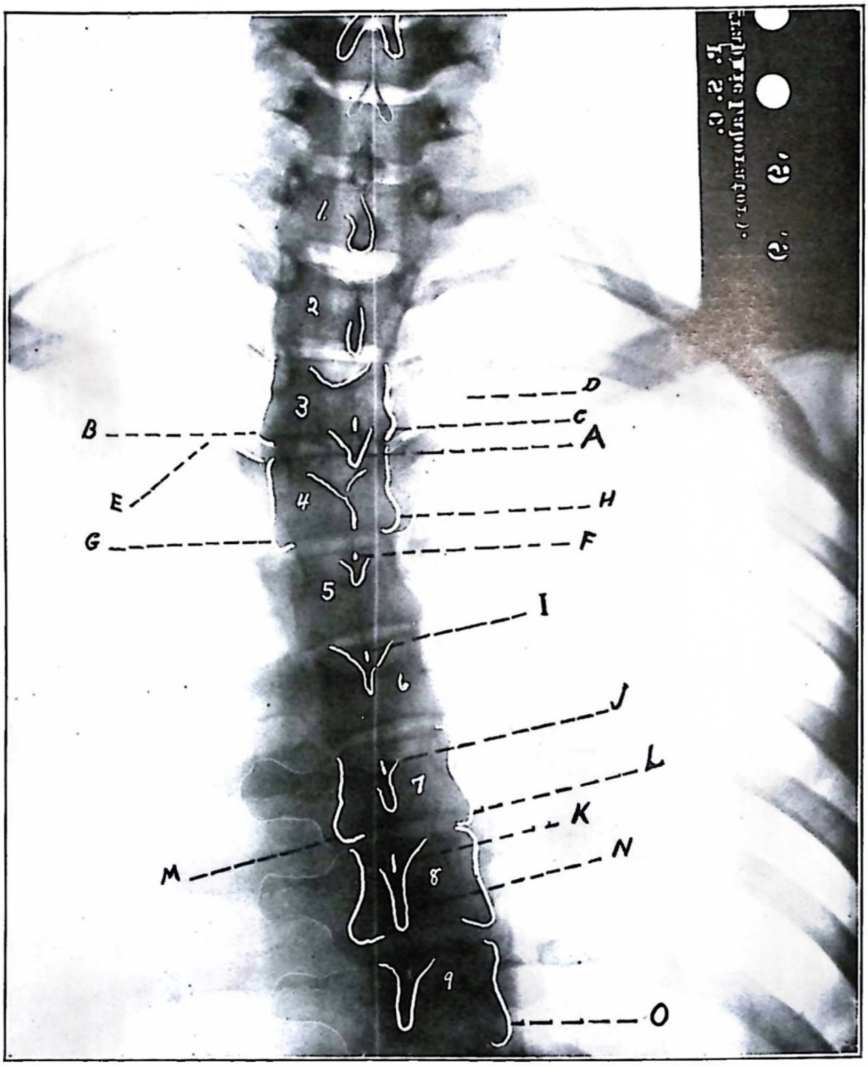


Fig. 7.

RULES AND READING OF FIG. No. 7

Rule No. 5.

Letter A represents spinous process of the 3rd dorsal vertebra.

Letters B and C outer edges of the body.

Measuring the distance from the center of the spinous process A to the edges of body B and C, we find the distance between A and C to be greater than from A to B; so we have proven it to be a right subluxation, even though the spinous process A is to the left of our imaginary median line. The same is true of letter F, which represents center of spinous process of the 4th dorsal, making same comparisons from F to G and F to H.

The fact that these spinous processes are nearer the right edge of bodies, even though the spinous processes are to the left of the median line, shows there is a rotation of these bodies of the vetebræ, which in this case is a left rotation or a left rotatory scoliosis.

Next consider letters D and E, which represent the transverse processes of the 4th dorsal vertebra. We find D is superior to E; adding this to our laterality which was found to be right, we then list the 4th dorsal as a right and superior subluxation.

Letter I represents spinous process of the 5th dorsal showing it near the median line.

Letter J represents spinous process of the 6th dorsal which you will notice overlaps the body of the 7th dorsal, due to the fact that the spinous processes in this region of the spine are very long.

And you will also note spinous processes of the 4th, 5th, 7th and 8th dorsal overlap the body below. **Be very careful of this fact when reading plates of this region.**

Letter K represents spinous process of 7th dorsal.

Letters L and M outer edge of body. On measuring between letters K and L and K and M we find the lesser distance between K and M, which proves it to be a left subluxation, altho spinous process is to the right of the median line.

Letter N represents tip of spinous process of 7th dorsal, which you will notice is to the right of center of K, which is center of spinous process. This indicates a bent spinous process to the right.

Letter O represents edge of body of the 9th dorsal. Comparing this with letter L, which is the edge of the body of 7th dorsal, we find it rotated farther to the right, which gives a right rotation of the lower dorsal vertebræ.

If this was a left lateral scoliosis you would find the spinous process nearer the left edge of the bodies in the upper dorsal.

In the lower dorsal, if you found the spinous processes nearer the right edge of bodies you would have a right lateral scoliosis.

Our spinographic listing would be as follows:

3rd dorsal R.
4th dorsal RS.
7th dorsal L.
With a left rotation from the 2nd to the 5th dorsal incl. and a right rotation from the 6th dorsal down.

RULES AND READING OF FIG. No. 8

Rule No. 6.

Letter A represents spinous process of 1st dorsal.

Letters B and C are outer edges of the body.

First determine your laterality by measuring the distance between A and B and A and C. We find the distance is less between A and C, therefore a right subluxation.

To determine inferiority and superiority of this vertebra you must first take into consideration the right transverse process, which is superior to the left transverse process; next consider the angle of the superior and inferior border of the body from right to left, which still proves that the RT is superior. So we list it as an RS subluxation.

Figure No. 8 also shows a right rotary scoliosis, extending from the 3rd to 7th dorsal inclusive, and a left rotatory scoliosis from the 8th dorsal down.

Letter D represents spinous process of 3rd dorsal, and on measuring we find the distance is greater between D and E than D and F, making it a left subluxation even tho it is curved to the right with a rotation. Also notice the tipping of this vertebra inferior on the left, making it an LI subluxation.

Letter G represents center of spinous process of 5th dorsal; H and I outer edges of body, measurement proves a left subluxation. You will also notice that letter J is tip of the spinous process which is bent to the right of center which, under palpation, would be listed as right.

Letter K, spinous process of 8th dorsal, showing how it overlaps body of 9th dorsal.

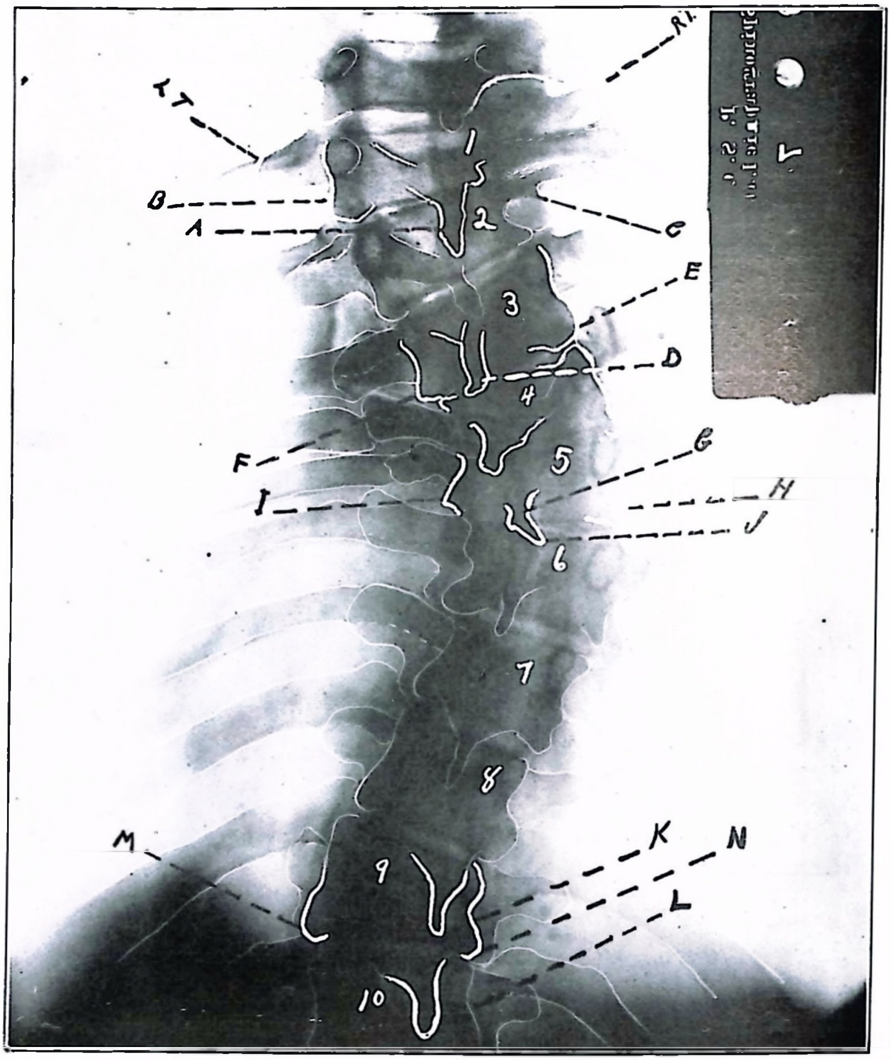


Fig. 8.

Letter L spinous process of 9th dorsal.

Letters M and N outer edges of body. On measurement from L to M and L to N we find spinous process nearer N than M, making a right subluxation. Notice tipping of this body inferior on right side, so our listing is RI. The curve is left in this region, therefore a left rotatory scoliosis.

Our spinographic would be as follows:

1st dorsal RS.
3rd dorsal LI.
5th dorsal L, with a bent spinous process to the right.
9th dorsal RI.
With a right rotation from the 3rd dorsal to the 6th dorsal inclusive
With a left rotation from the 8th dorsal down.

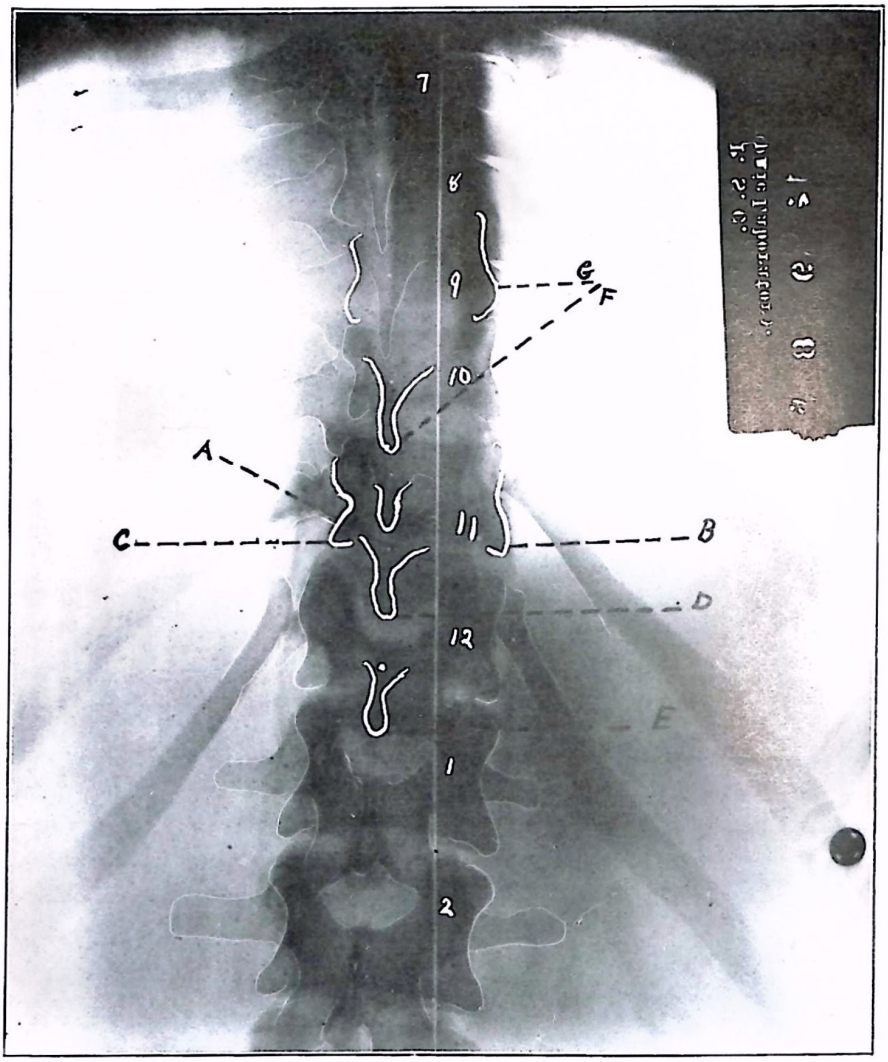


Fig. 9.

RULES AND READING FOR FIG. No. 9

In determining laterality of the vertebræ in Fig. No. 9 we refer back to Rule No. 4.

Letter A represents spinous process of 11th dorsal. B and C outer edges of body. On measurement we find that we have a left subluxation, while the tip of the spinous process D is bent slightly to the right and upon palpation with a comparison of spinous processes of the 10th and 12th dorsal vertebræ, it would be listed as a right subluxation, while in reality it is left.

Letter F represents spinous process of 9th dorsal.

Letter G the body of the 9th dorsal showing the length of this spinous process and how it overlaps the body of the 10th dorsal and upper part of the 11th. There is a scoliosis to the right, while the processes are nearer the left edges of the bodies, showing that it is a right rotatory scoliosis.

Our spinographic listing would be as follows:

> 11th dorsal L with a bent spinous process to the right, with a right rotation extending from the 7th dorsal to the 2nd lumbar inclusive, 11th dorsal being the apex of this right rotation.

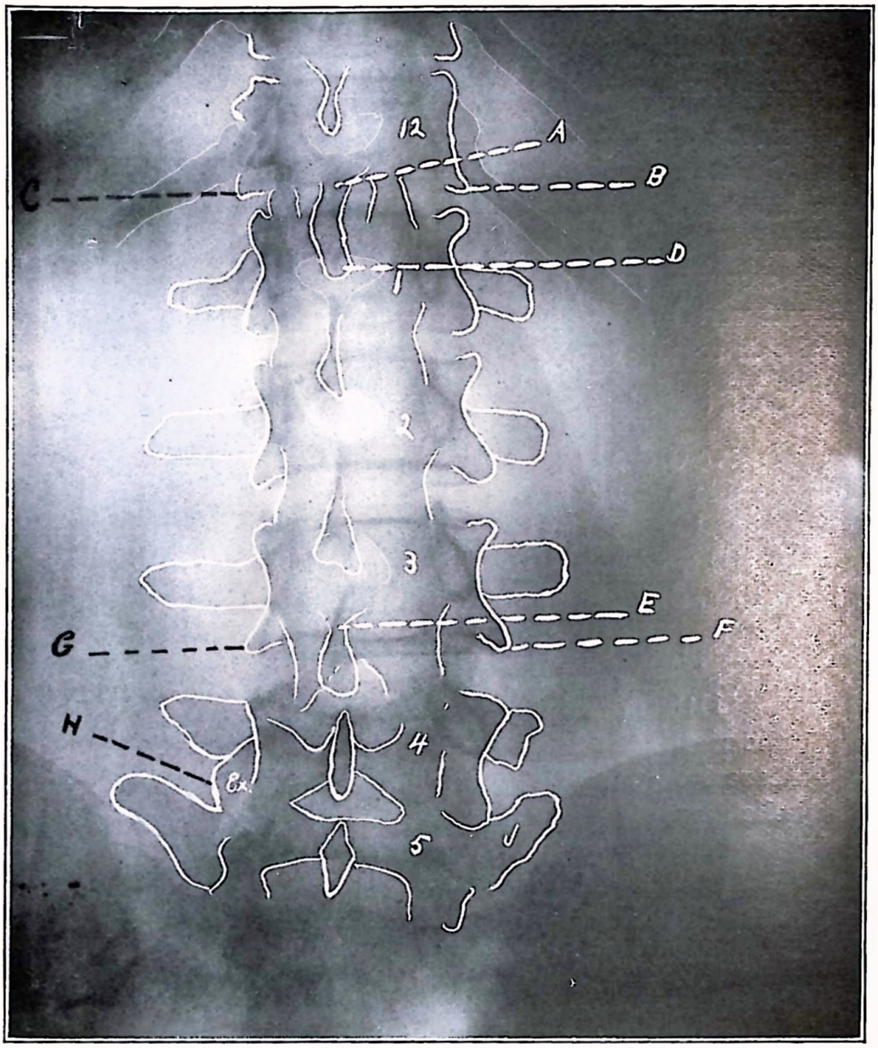


Fig. 10.

RULES AND READING OF FIG. No. 10

We determine laterality in the lumbar region the same as in Rule No. 4, by the comparative measurements from spinous processes to the edges of the bodies.

Almost all lumbar plates take in the 12th dorsal.

Letter A represents center of spinous process of 12th dorsal.

Letters B and C outer edges of body.

In comparing the distance from A to B and A to C we prove it to be a left subluxation. With the tip of spinous process D bent to the right of center of A, spinographic listing would be a left subluxation with bent spinous process to the right.

Letter E represents center of spinous process of 3rd lumbar.

Letters F and G outer edges of body.

On measurement we find we have a left subluxation. Also considering the inferiority and superiority we find the left side to be superior, so we add this to our laterality, which would be listed as follows: 3rd lumbar L and slightly superior.

Letter H shows an exostotic growth between the bodies of the 4th and 5th lumbar vertebræ. There is also a slight rotatory scoliosis in this region.

Our spinographic listing would be as follows:

12th dorsal L with a bent spinous process to the right.

3rd lumbar LS with an exostosis and ankylosis between the 4th and 5th lumbar vertebræ.

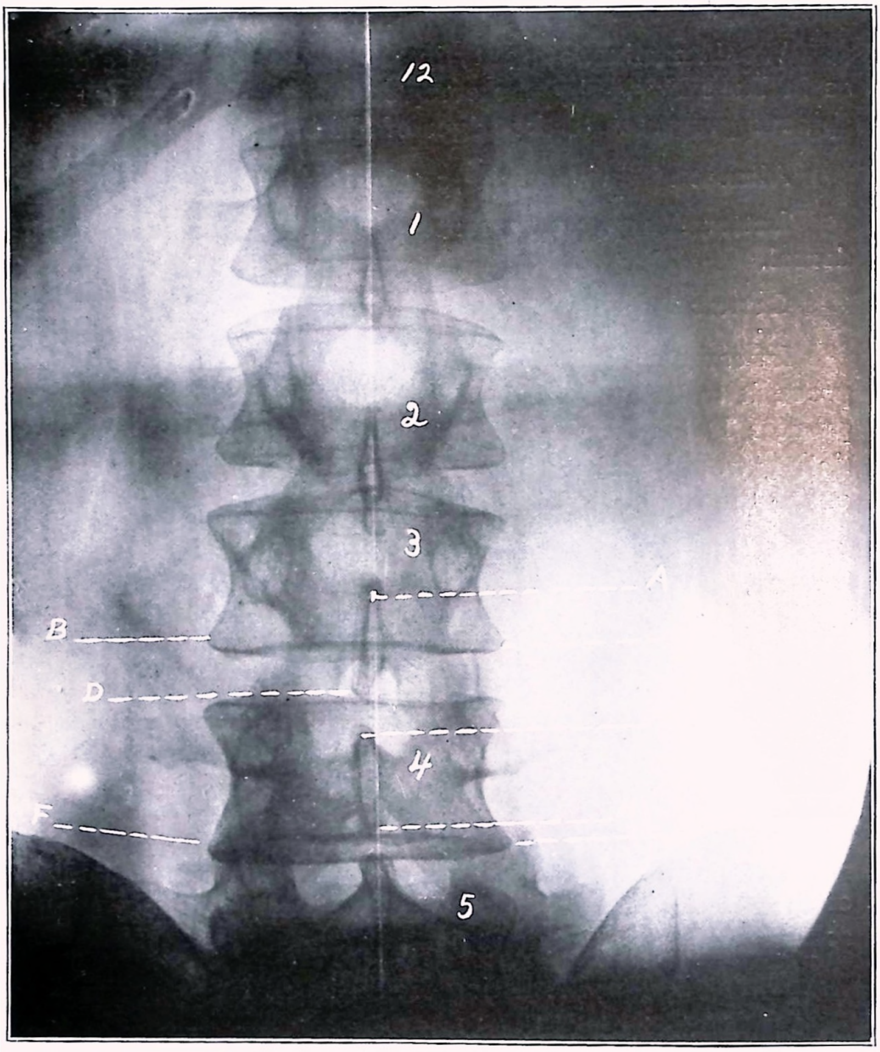


Fig. 11.

RULES AND READING FOR FIG. No. 11

The laterality in this figure is determined in using Rule No. 4.

You will notice upon close examination that there is very little laterality of the vertebræ by comparing one spinous process with another as far as the eye can detect, but upon measurement we find there is laterality to the 3rd and 4th lumbar vertebræ.

Letter A represents center of spinous process of the 3rd lumbar vertebra.

Letters B and C the outer edges of the body of the vertebræ.

Upon measurement we find that A is nearer to C and farther away from B showing that the spinous process is to the right of the median line of the vertebra itself.

Letter D represents the tip of the spinous process of the 3rd lumbar vertebra, which upon careful examination, is found to be to the left of its center A, proving that we have a right subluxation with a bent spinous process to the left. In considering the 4th lumbar vertebra notice that the center of the spinous process E is to the left of letter A, but still upon measurement from E to F and E to G we find that E is nearer G than F, proving that it is a right subluxation even tho the center of spinous process E is to the left of the center of spinous process A.

Letter H represents the tip of the spinous process of the 4th lumbar vertebra, showing that it is to the right of its center E, indicating a bent spinous process to the right, even tho our laterality is found to the right. Com-

paring the tip of spinous process D, which is bent left with tip of spinous process H, it can be seen that upon palpation D would palpate to the left of H.

Our listings would be as follows:

3rd lumbar subluxated right with a bent spinous process to the left.

4th lumbar a right subluxation—spinous process also bent right.

Spinographic listing as follows:

3rd lumbar R bent spinous L.
4th lumbar R spi also bent R.

RULES AND READING FOR FIG. No. 12

Figure No. 12 presents a condition which refers us back to Rule No. 5, in how to determine a rotatory scoliosis. It can be easily seen that we have a curvature to the right, and we must determine whether or not we have a rotatory scoliosis or a lateral scoliosis.

First we will take letter A, which is the center of the spinous process of the first lumbar vertebra, measuring the distance from there to B and C, which is the outer edge of the body of this vertebra, and we find that A is nearer to C and farther away from B, proving that this spinous process is to the left of the median line of the vertebra itself; therefore our laterality would be left. Notice there is a tipping to the inferior upon the left side, which is more adaptative to the scoliosis than being an inferior subluxation. You will always notice in rotations that there is a tipping inferiorly in the upper part of a rotation while they are tilted to the superior in the lower part of a rotation.

Letter D represents the spinous process of the 12th

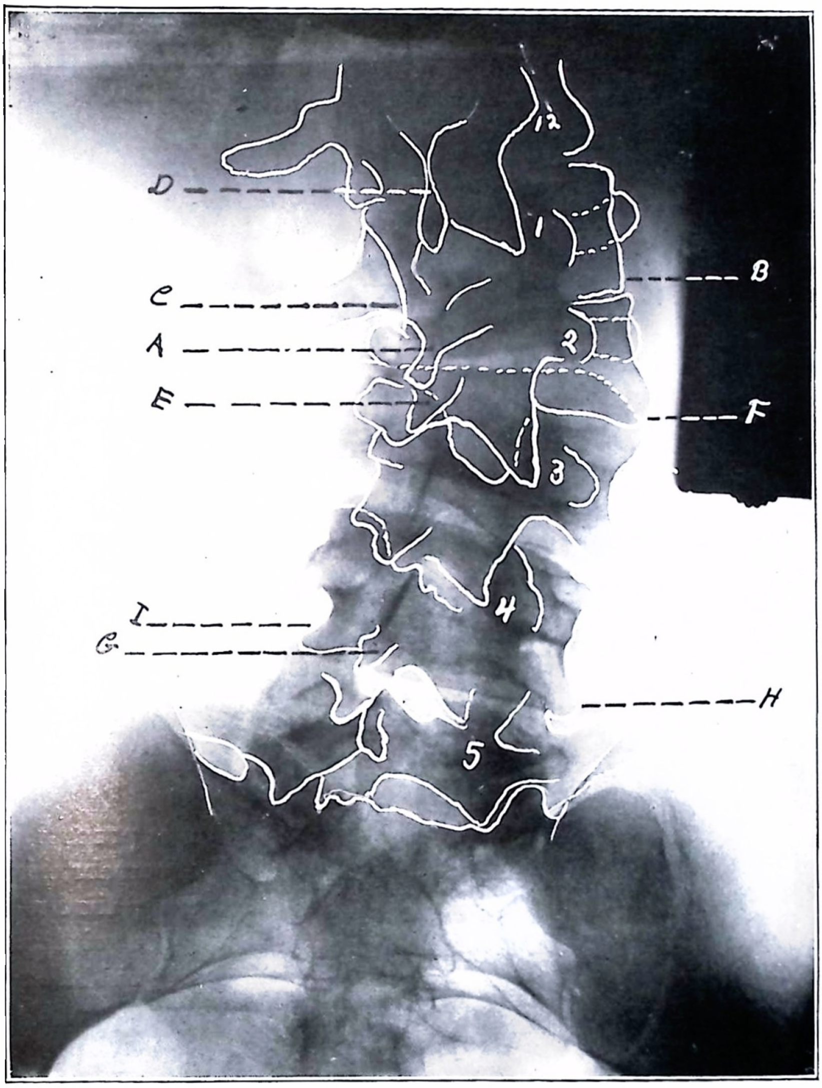


Fig. 12.

dorsal vertebra showing how it overlaps the body of the first lumbar vertebra.

Letter E represents the center of the spinous process of the 2nd lumbar vertebra.

Letter F the right edge of the body.

You will notice upon measurement that E is very far away from F and closer to the left edge of the body. You will notice that the left edge of this body is not lettered, as the body itself is wedge-shaped with ankyloses between the first, second and third lumbar vertebræ; also we find that letter F is farther to the right than the body above or below it, proving that this is the apex of this scoliosis.

Letter G represents the center of the spinous process of the 4th lumbar vertebra.

Letters H and I the outer edges of the body of the vertebra. Measuring the distance from G to H and G to I we find that G is nearer I and farther away from H, proving that this spinous process is to the left of the median line of the vertebra itself; also that I is much higher or superior to H.

Therefore our findings prove that the spinous processes are nearer the left edges of the bodies of the vertebræ in this region while the curvature is right, showing that we have a right rotation of the bodies of the vertebræ with all the spinous processes being left; this condition would then be listed as a right rotatory scoliosis or rotation.

Our spinographic listing would be as follows:

1st lumbar LI.
2nd lumbar L, with cord pressure.

4th lumbar LS.

With a right rotation of the bodies of the vertebræ, 2nd lumbar as apex; with ankylosis between bodies of 1st, 2nd and 3rd lumbar vertebræ.

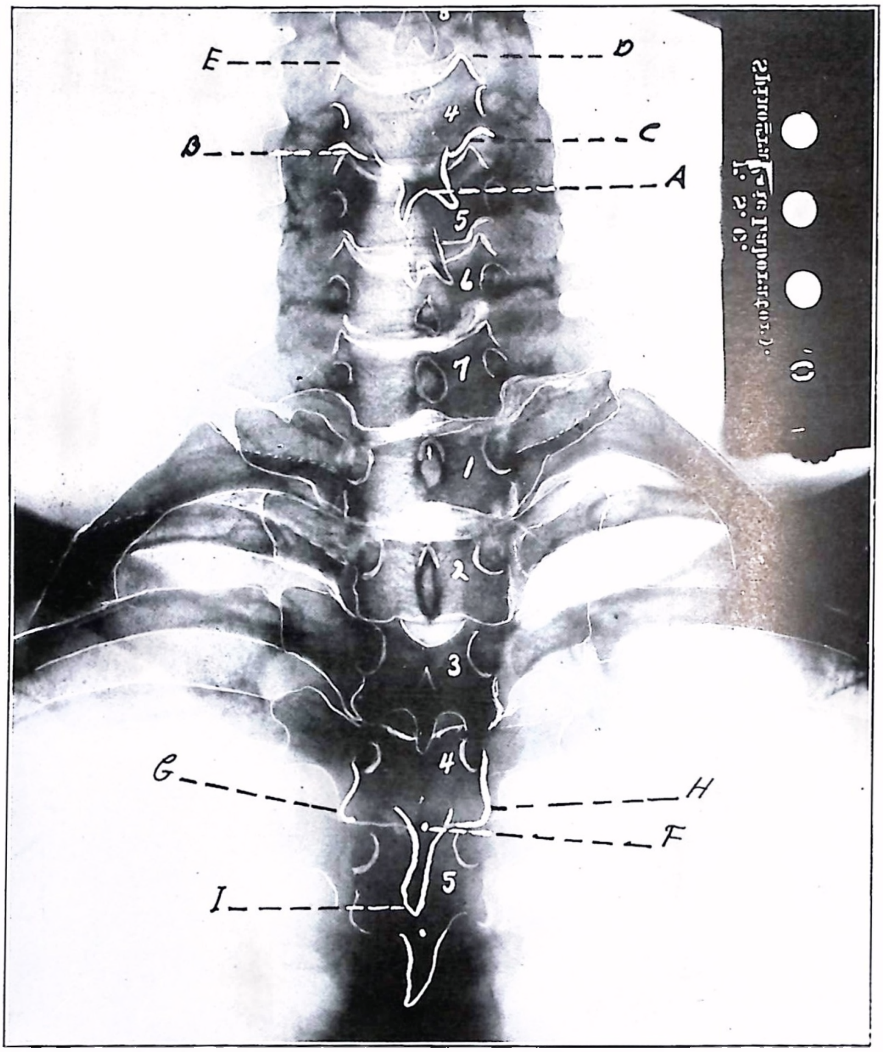


Fig. 13.

RULES AND READING OF FIG. No. 13

Rule No. 7.

Letter A represents the center of the spinous process, or bifurcation of the 4th cervical vertebra; B and C the outer edge of the body.

On measuring the distance from A to B and A to C we find that A is nearer to C and farther away from B, proving that the laterality is to the right.

Letters D and E represent the superior outer edge of the body of the 4th cervical vertebra. You will find that D is higher than E, also that C is higher than B, showing that the right side of this vertebra is superior to the left side of the vertebra, making it a right superior subluxation.

Letter F represents the highest point or center of the lamina where they meet to form the spinous process.

Letters G and H represent the outer edges of the body of the vertebra.

Upon measurement we find that F is nearer to H and farther away from G, proving that we have a right subluxation of the 4th dorsal vertebra.

Letter I represents the tip of the spinous process of the 4th dorsal vertebra, which is found to be to the left of its center F, showing that we have a bent spinous process to the left; you will also notice how this spinous process overlaps the body of the 5th dorsal vertebra. It is in this region that the spinous processes are longer and we will find this overlapping.

Our spinographic reading would be as follows:

4th cervical RS.

4th dorsal R, with a bent spinous process to the left.

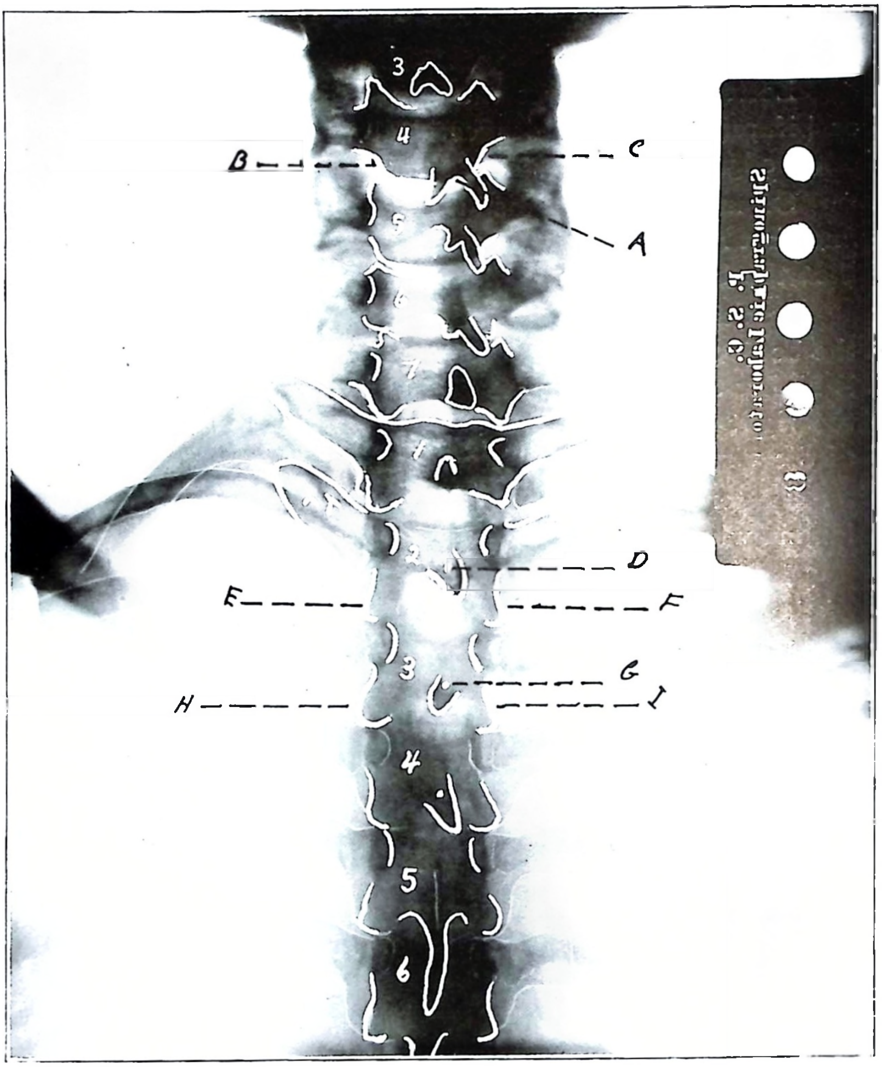


Fig. 14.

RULES AND READING FOR FIG. No. 14

Fig. No. 14 represents a spinograph of the lower cervical and upper dorsal vertebræ. The same rule applies for reading as Fig. No. 13.

Letter A represents the center of the spinous process of the 4th cervical vertebra; B and C the outer edge of the body of the vertebra.

Upon measurement we find that letter A is much nearer C and farther away from B, showing that the laterality of this spinous process is to the right. Compare the center of this bifurcation, it is found to be very much to the right of the one above it, also the spinous processes of the 5th, 6th and 7th cervical vertebræ are very much to the right, also producing a slight right scoliosis in this region.

Letter D represents the spinous process of the 2nd dorsal vertebra; E and F the outer edge of the body of the vertebra. Upon measurement we find that D is nearer F and farther away from E proving that we have a right subluxation. This spinous process is also bent to the right.

You will also notice that the left transverse process marked LT is much higher than the right transverse process marked RT, while the body of the vertebra itself appears to be level, showing then that the left transverse process is bent superiorly.

Letter G represents center of spinous process of the 3rd dorsal vertebra; H and I the outer edges of the body of the 3rd dorsal vertebra.

Upon measurement we find that G is nearer I and farther away from H, showing that our laterality is to the right; also notice that the tip of this spinous process is

Fig. 15.

bent to the left and upon palpation would palpate to the left of the tip of the spinous process above it and below it. when in reality it is to the right of the median line of the vertebra itself.

Our spinographic listing would be as follows:

4th cervical	R.
2nd dorsal	R, spinous also bent right.
3rd dorsal	R, with spinous bent left.

RULES AND READING OF FIG. No. 15

Figure 15 takes in atlas and axis.

Rule No. 8.

Letter A represents spinous process or center of the bifurcation of the axis; B and C the upper outer edges of the body of the axis.

Measuring the distance from A to B we find that A is nearer C and farther away from B, proving that the spinous process is to the left of the median line of the vertebra itself; D representing the center of the odontoid process of the axis we find that A is also to the left of D, while in the normal they should be in alignment; our laterality of the axis would then be listed as left. Comparing B with C we find that C is much lower than B making this axis inferior on the left side; adding this inferiority to our laterality would make it LI.

Letter E represents the outer lower edge of the right lateral mass of the atlas; F, the left lateral mass of the atlas. Comparing E with B we find it to the right of B; comparing F with C we find it also is to the right of C. After making this comparison we then take into consideration the

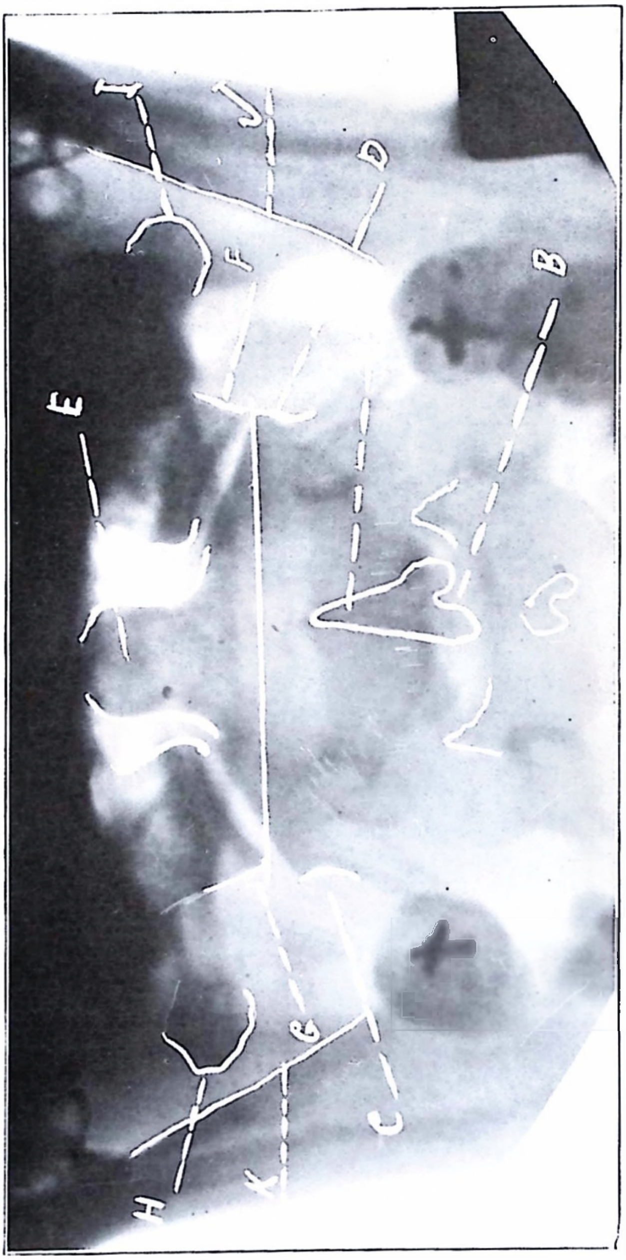


Fig. 16.

spaces found between the odontoid process and inner margin of the lateral masses of the atlas showing that the space on the right of the odontoid is much greater than that on the left. Remember that your axis is tipped inferior on the left and you will find the odontoid process D is tilted slightly left also. This condition would help to make the space greater on the right side of the odontoid process if this atlas were normal.

Letters G and H represent the transverse processes of the atlas; I and J the rami of the jaw. First measure the width of I comparing it with the width of J. If found to be of equal distance, measure from E to the inner or outer edge of I, comparing your findings with F to the inner or outer edges of J.

After making this comparison we find that E is nearer I, and F is farther away from J, proving with all points considered that the laterality of the atlas is to the right.

Drawing a line from either E to F or G to H, we find that the atlas is higher on the right side than on the left. Adding this to our laterality we would have an RS subluxation of the atlas.

Our spinographic listing would be as follows:

Atlas RS.
Axis LI.

RULES AND READING FOR FIG. No. 16

Atlas and axis. Rule No. 8 also applies to this figure.

Letter A represents the center of spinous process and B the center of the bifurcation of the spinous process of the axis.

Letters C and D represent the outer upper edges of the axis.

Measuring the distance from either A or B to C and D we find that A and B are nearer D and farther away from C; also that A and B are to the right of the center of the odontoid process E, proving that our laterality of the axis is to the right.

Comparing the upper margin of D with the upper margin of C we find that D is higher or superior to C, showing that our axis is also superior upon the right side.

Letter F represents the outer and lower edge of the right lateral mass of the atlas; G the outer lower margin of the left lateral mass of the atlas.

Comparing F with D we find them in alignment; comparing G with C we find that C is to the left of G due to the fact that the body of the axis is rotated to the left of G.

H and I represent the transverse processes of the atlas; J and K represent the rami of the jaw.

Using our measurements from F to J; comparing our findings from G to K with all other points considered, we find that the atlas is practically normal in respect to laterality. We find that the space between the odontoid process and inner margin of the right lateral mass is greater than the space found upon the left, due to the fact that as the axis has tilted right and superior it has thrown the odontoid to the left or away from the right lateral mass of the atlas, thereby causing this space to be greater.

Comparing F with G we find that F is tipped higher or superior to G. This tipping of the atlas is adaptative to the subluxation of the axis.

Our spinographic listing would be as follows:
Axis RS.

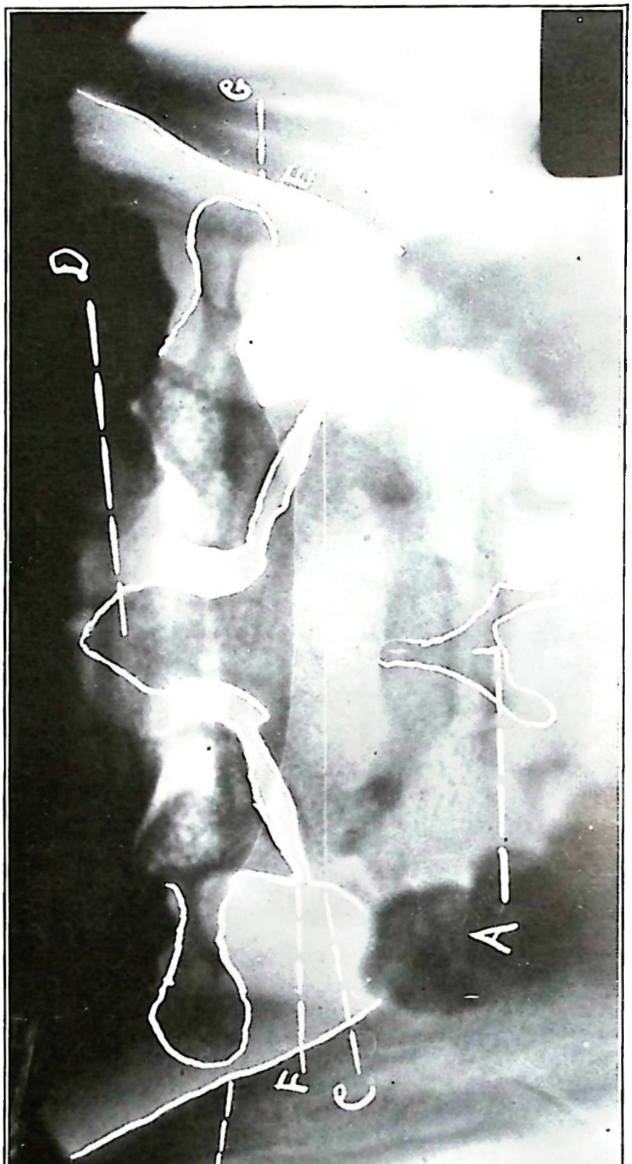


Fig. 17.

RULES AND READING FOR FIG. No. 17

Atlas and axis. Rule No. 8 also applies to this figure.

Letter A represents the center of the spinous process, or bifurcation of the axis; letters B and C the outer upper edges of the axis.

Measuring the distance from A to B and from A to C, we find that A is nearer to C and farther away from B, showing that the laterality of the spinous process is to the left. Letter D being the center of the odontoid process we find that A is to the left of it.

Letter E represents the outer lower edge of the right lateral mass of the atlas. Letter F represents the outer lower edge of the left lateral mass of the atlas.

Comparing E with B we find them in alignment; comparing F with C we also find them in alignment. Measuring the distance from E to the inner or outer edge of the rami of the jaw and comparing our findings with the distance from F to the inner or outer edge of the rami of the jaw, we find them equal; also we find that the spaces on either side of the odontoid process and the inner margin of the lateral masses are equal, proving that there is no laterality to the atlas.

G and H represent the transverse processes of the atlas, showing that H and F are slightly superior to G and E. This slight tilting is being produced adaptatively to the subluxation of the axis, as C is a trifle higher than B, making the axis slightly superior on the left side. Notice the long prong upon the right side of the bifurcation of the axis, which under palpation might be misleading.

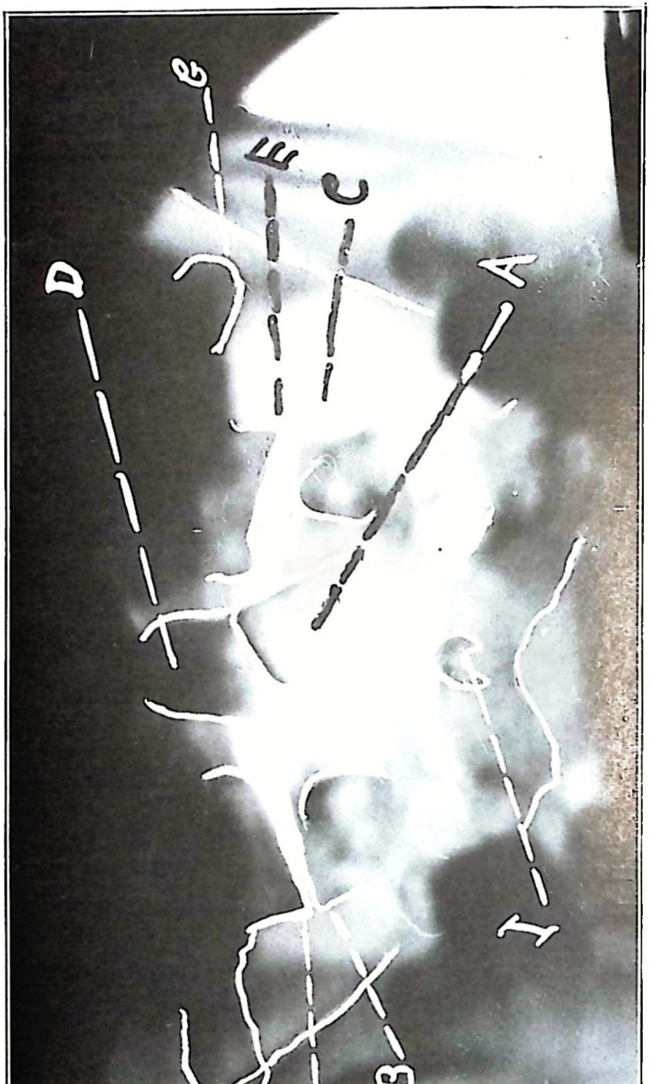


Fig. 18.

Our spinographic listing would be as follows:
Axis L, with slight superiority.

RULES AND READING FOR FIG. No. 18

Atlas and axis. Rule No. 8 also applies to this figure.

Letter A represents center of spinous process or bifurcation of the axis; letters B and C the outer upper edges of the body of the axis.

Measuring the distance from A to B and A to C we find that A is nearer to C and farther away from B, showing that our laterality of the spinous process is to the right. Letter D representing the center of the odontoid process, we find that A is also to the right of it.

Comparing B with C we find that C is higher or superior to B, making it superior upon the right side, so that our listing would be RS on the axis.

Letter E represents the outer lower edge of the right lateral mass of the atlas; letter F representing the outer lower edge of the left lateral mass of the atlas. Comparing E with C we find that E is to the left of C. Comparing F with B we find that it is to the left of B showing that our lateral masses of the atlas are to the left of the body of the axis. Comparing the spaces found on either side of the odontoid process, we find the space on the left is greater than found upon the right, even tho our odontoid process D is tilted to the left. Measuring the distance from E to the inner or outer edge of the rami of the jaw and comparing our findings with the distance from F to the inner or outer rami of the jaw, we will find that the left lateral mass

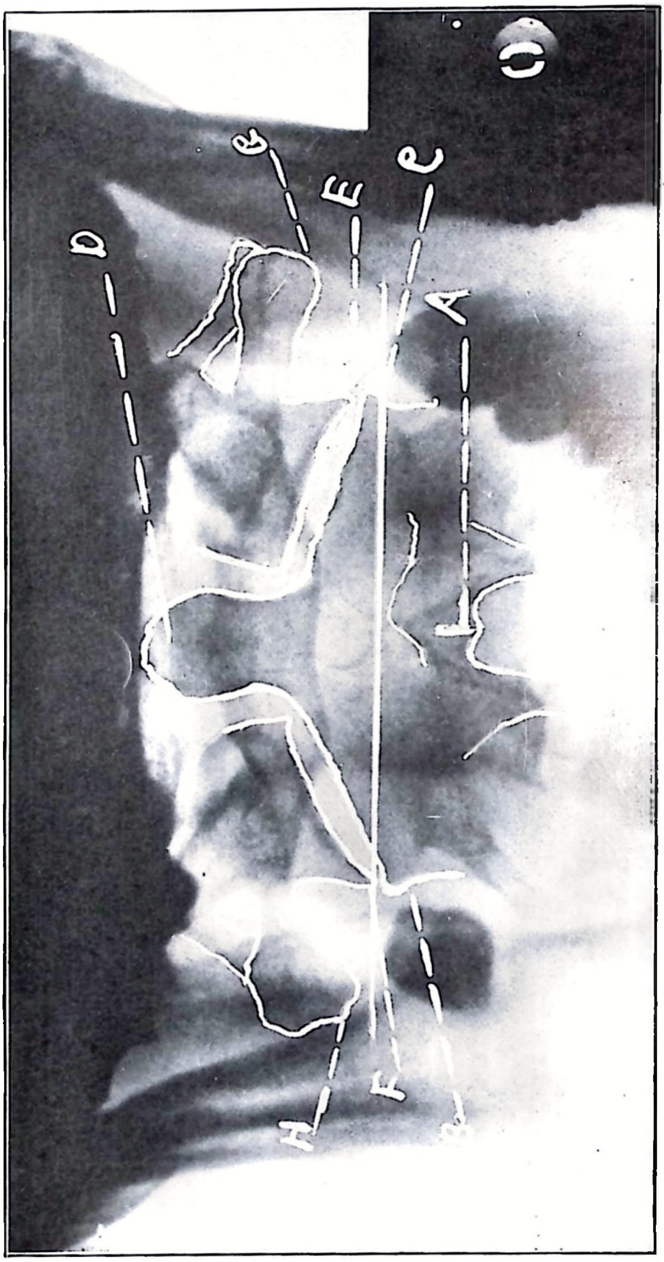


Fig. 19.

of the atlas is nearer the left rami of the jaw, and farther away from the right.

Having considered all other points for laterality we would list the laterality of the atlas as being left.

Letters G and H represent the transverse processes of the atlas.

Comparing H and F with G and E, we find that H and F are lower and inferior to G and E, adding to our laterality inferiority of the atlas.

Letter I represents the center of the bifurcation of the 3rd cervical vertebra, showing how small this spinous process is in comparison with the spinous process of the axis.

Our spinographic listing would be as follows:

Atlas LI.
Axis RS.

RULES AND READING FOR FIG. No. 19

Atlas and axis. Rule No. 8 also applies to this figure.

Letter A represents the center of the spinous process or bifurcation of the axis; letters B and C the outer upper edges of the body of the axis.

Measuring the distance from A to B and A to C we find that the laterality of the spinous process is slightly to the right; comparing B with C we find that C is superior to B.

Letter D represents the center of the odontoid process.

Comparing A with D we find that A is also to the right of D; our listing would then be axis RS.

Letter E represents the outer lower edge of the right lateral mass of the atlas; letter F represents the outer lower edge of the left lateral mass. Comparing E with C we find them in alignment. Comparing F with B we find that B is left of F, which is due to the fact that the body of the axis is rotated on this side. Comparing the spaces found on either side of the odontoid process they appear to be normal Measuring the distance from E to the inner or outer edge of the rami of the jaw and comparing our findings with the distance from F to the inner or outer edge of the rami of the jaw, we find them equal. Thus proving, with all other points being considered to determine laterality of the atlas, that there is no laterality of this atlas.

Letters H and G represent the transverse processes of the atlas.

Comparing H and F with G and E we find that G and E are tipped superior to H and F, but notice that the spaces on either side of the odontoid process and lateral masses, and the articulating spaces between the lateral masses and the body of the axis have not changed. This shows that the tipping of the lateral masses is adaptative to the tipping of the axis. Also compare the left transverse process H with the right transverse process G; carefully note their difference in shape and angle which they assume away from the lateral masses.

You will find therein that the left transverse process H is thicker and is bent inferior illustrating the fact that it is possible to have bent transverse processes upon the atlas

as well as bent spinous processes of other vertebræ which are very misleading in palpation.

Our spinographic listing would be as follows:

Axis RS, with a bent transverse process inferiorly on the left of the atlas.

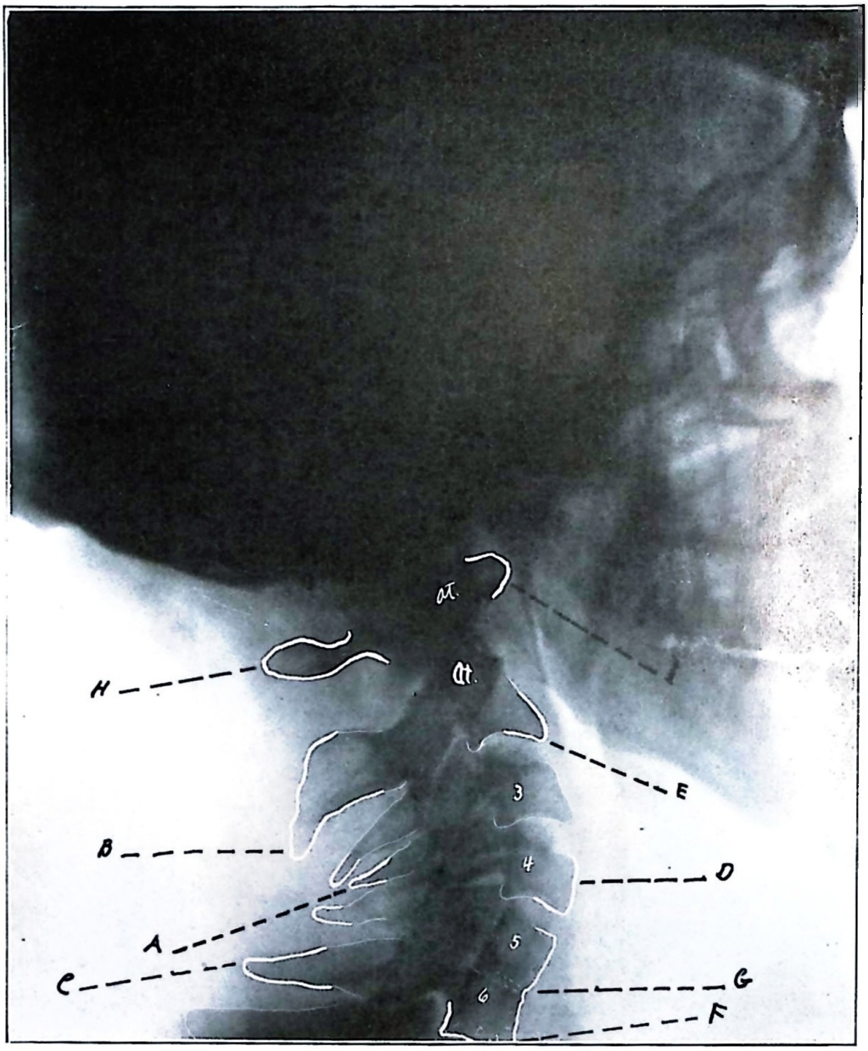


Fig. 20.

RULES AND READING FOR FIG. No. 20

Also covered by Rule No. 8.

Reading lateral views of the cervical vertebræ.

Lateral views of the cervical vertebræ are taken for the purpose of determining the following conditions: posteriority and anteriority, superiority and inferiority, dislocations, fractures, exostoses and ankyloses. The reason that these conditions are shown more plainly in a view of this kind than in an anterior-posterior view is that the shadows of the lower maxillary and teeth do not interfere.

Letter A represents the spinous process of the 4th cervical vertebra, which is found to be anterior to the spinous process above it and the one below it. Letter B represents the spinous process of the axis showing how much longer it is than the spinous process of the 3rd, 4th and 5th cervical vertebræ. Letter C represents the spinous process of the 6th cervical vertebra showing that it is longer also.

Letter F represents the anterior, inferior edge of the body of the 6th cervical vertebra. Comparing C with F we find that C is superior to F and would be listed as PS.

Letter D represents the anterior edge of the 4th cervical vertebra. Comparing it with the one above and below we find that it is anterior.

Letter E represents the anterior and inferior edge of the body of the axis. Comparing B with E we find it inferior to E making our listing here posterior and inferior, or PI.

Letter H represents the posterior ring of the atlas.

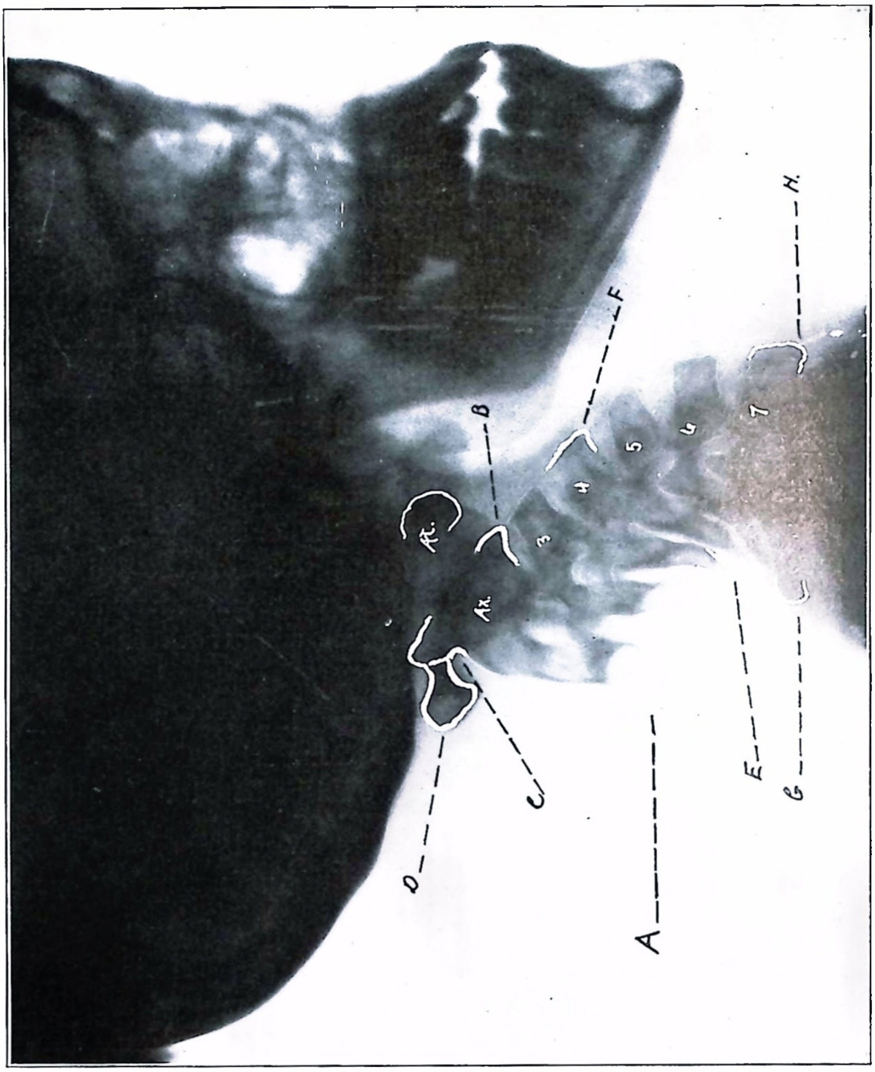


Fig. 21.

Letter I represents the anterior ring of the atlas. Comparing H with I we find that H is inferior to I while normally they should be practically level. The same is true of B and E.

Letter G represents the intervertebral disc between the 5th and 6th cervical vertebræ, showing that it has been absorbed and that ankylosis has taken place between the bodies of these two vertebræ.

Our spinographic listing would be as follows:

Axis PI.

6th cervical PS, with ankylosis between the bodies of the 5th and 6th cervical vertebræ and a lordosis in the middle cervical vertebræ.

RULES AND READING FOR FIG. No. 21

Are also covered by Rule No. 8.

Reading lateral views of cervical vertebræ.

Figure 21 presents a case of cord pressure between atlas and axis, letter A representing the spinous process of the axis; letter B the anterior and inferior edge of the body of the axis; letter C represents the odontoid process of the axis; letter D the posterior ring of the atlas.

Comparing the angle from A to B we find that A is very much inferior to B, with the odontoid process C tilted backward into the posterior ring of the atlas D, producing pressure on the spinal cord.

Letter E represents the spinous process of the 4th cervical vertebra; letter F the inferior and anterior edge of the body of the 4th cervical vertebra. Comparing the angle from E to F we find that E is also inferior to F.

Fig. 22.

Letter G represents the spinous process of the 7th cervical vertebra; letter H the inferior and anterior edge of the 7th cervical vertebra. Comparing the angle from G to H we find that G is superior to H.

Our spinographic listing would be as follows:

Axis	PI, badly.
7th cervical	PS.

While the inferiority of the 4th cervical vertebra is adaptative to the acute posteriority and inferiority of the axis.

RULES AND READING OF FIG. No. 22

Also covered by Rule No. 8.

Reading lateral views of cervical vertebræ.

Figure 22 presents a case of cord pressure at the 4th cervical vertebra.

Letter A represents the spinous process of the 4th cervical vertebra; letter B the anterior edge of the body of the 4th cervical vertebra; letter C represents the articulating process of the 4th cervical vertebra showing how this articulating process has slipped posterior to the one above it. Comparing the anterior edge of the body B with the anterior edge of the bodies of the one above and below, it shows that it is also posterior, practically making a dislocation of the 4th cervical vertebra, which, in the medical world would be classed as a broken neck.

In the Chiropractic world this case was restored to normal articulation and health by Chiropractic adjustments.

Letter D represents the spinous process of the 6th

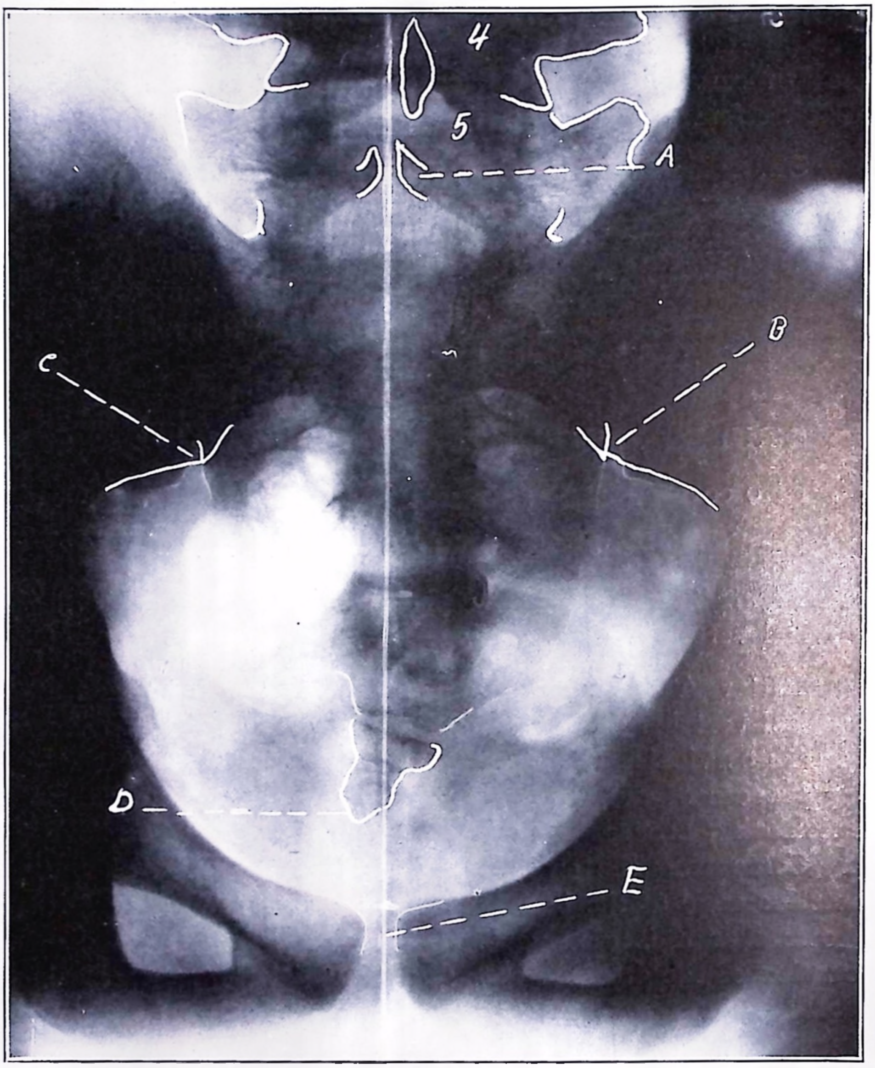


Fig. 23.

cervical vertebra; letter E represents the anterior edge of its body. Comparing the angle from D to E we find that D is inferior to E.

Letter F represents the posterior ring of the atlas which is tipped superior and very close to the occiput, this condition being adaptative to the kyphosis produced in the middle cervical vertebræ.

Our spinographic listing would be as follows:

4th cervical P, very much.
6th cervical PI.

RULES AND READING FOR FIG. No. 23

Rules No. 9 and 10 used.

To determine sacro-iliac and coccyx subluxations.

Letter A represents the right side of the spinous process of the 5th lumbar vertebra, showing that it has never united with the left side to form a complete spinous process. This condition would be listed as a cleft spine.

Letters B and C represent the lower border of the articulations of the sacrum and ilii on either side. It is from these borders that we determine whether or not the ilii are subluxated superior to their articulations with the sacrum.

Letter D represents the tip of the coccyx, which is found to be subluxated to the left of E, which is the center of the pubic articulation. Also notice that the spinous process of the 4th lumbar vertebra is to the right of the spinous process of the 5th lumbar vertebra. Upon measure-

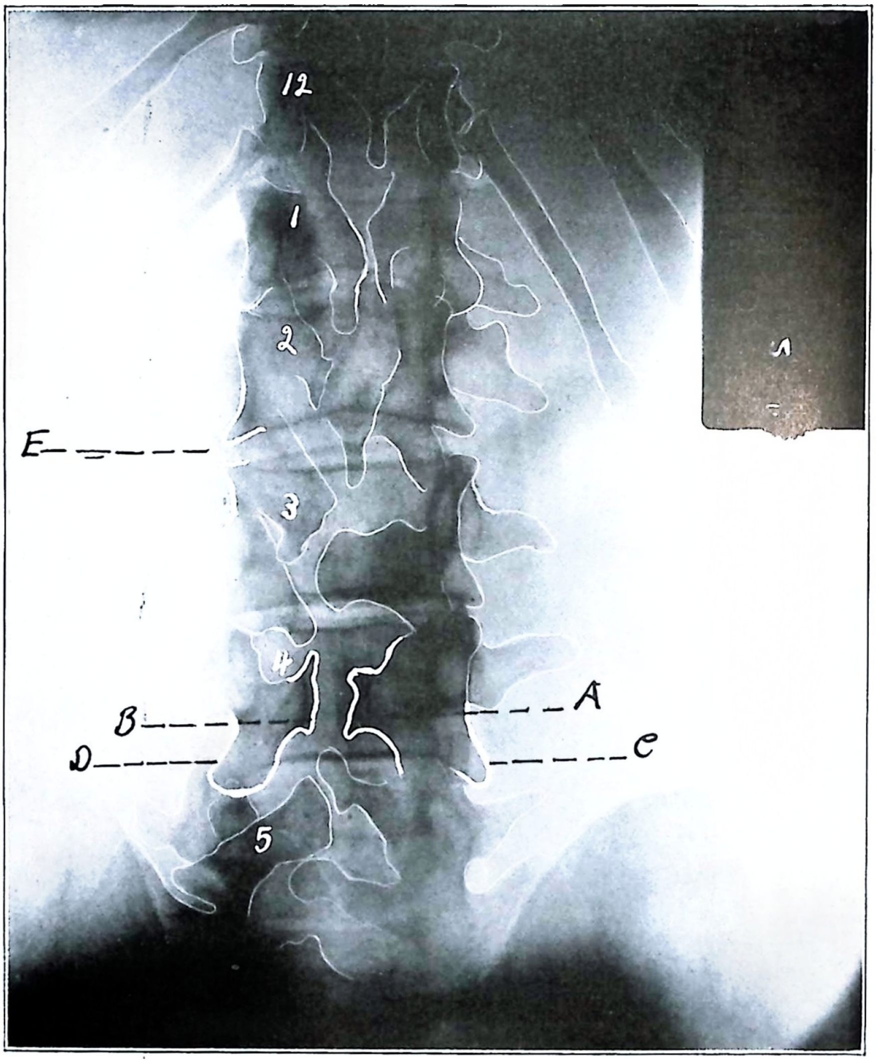


Fig. 24.

ment we would find that the 5th lumbar vertebra is subluxated to the left and superior.

Our spinographic listing would be as follows:

5th lumbar	LS, with a cleft spinous process.
Coccyx	L.

RULES AND READING FOR FIG. No. 24

Rule No. 11.

Always be on the lookout for other abnormal conditions, as you may find exostoses, ankyloses, curvatures, fractures, caries or tubercular conditions, etc.

Figure No. 24 presents an abnormal condition of the 12th dorsal and all the lumbar vertebræ other than subluxations.

Letter A represents the right lamina of the 4th lumbar vertebra, letter B representing the left lamina of the 4th lumbar vertebra. We find that the laminæ have never united to form a spinous process.

Letters C and D represent the outer edges of the body of the 4th lumbar vertebra. Measuring the distance from the center of the space found between the laminæ to C and D, we find that the center is nearer D and farther away from C, showing that we have a left sublaxation of the 4th lumbar vertebra.

Letter E shows the outline of an exostosis and ankylosis along the left edges of the bodies of the 2nd and 3rd lumbar vertebræ.

You will find that none of the laminæ in this lumbar region have united to form spinous processes, this condition is pre-natal and is termed a cleft spine. Where there is a

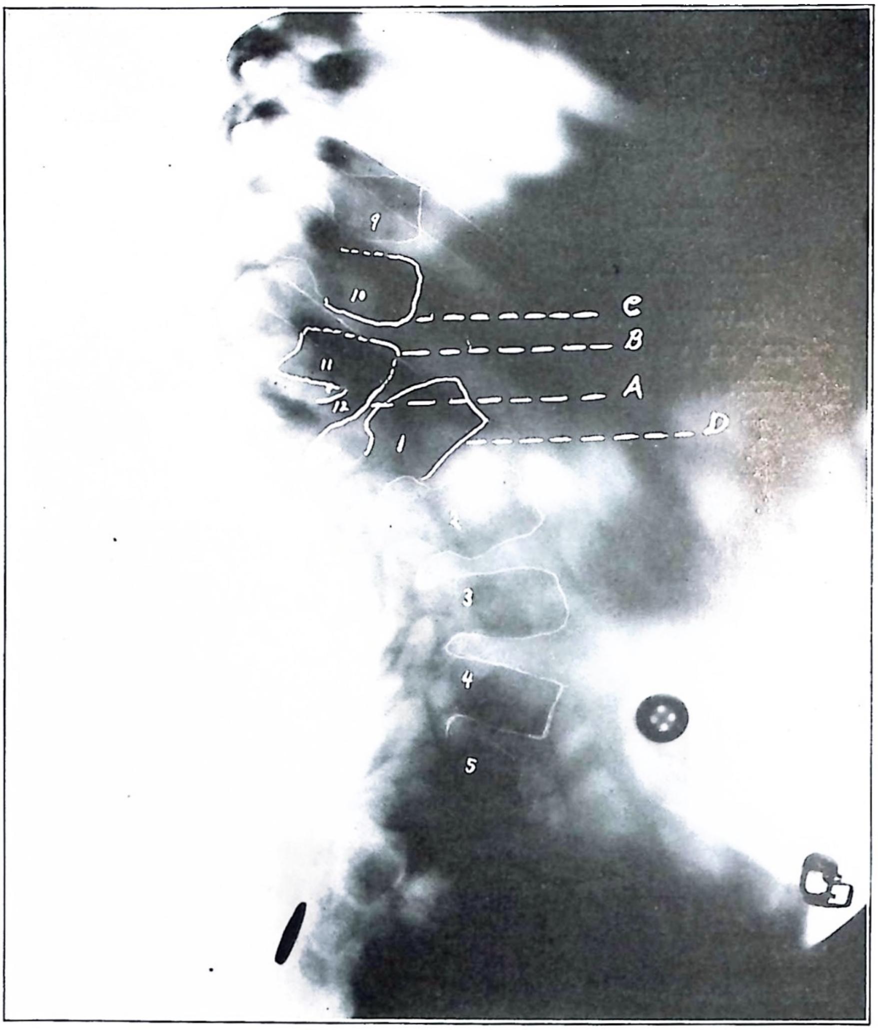


Fig. 25.

protrusion of the spinal cord or membranes it is termed Spina-bifida.

Our spinographic listing would be as follows:

4th lumbar L.

Exostoses and ankyloses between the 2nd and 3rd lumbar vertebræ with a cleft spine from the 12th dorsal to the 5th lumbar inclusive.

RULES AND READING FOR FIG. No. 25

This plate presents a lateral view of the lower dorsal and lumbar region. Rule No. 11 also applies to this plate.

Letter A represents what is left of the anterior edge of the body of the 12th dorsal vertebra; letter B represents the anterior edge of the body of the 11th dorsal vertebra; letter C represents the anterior edge of the body of the 10th dorsal vertebra; letter D represents the anterior and inferior edge of the first lumbar vertebra.

Comparing A with B and C we find that A is very much posterior to B and C. Comparing A and D we find that A is much more superior to D than either B or C; also that the body of the 12th dorsal vertebra A, is much thinner or more wedge-shaped than either B or D; also, that it is ankylosed anteriorly to the body of the 11th dorsal vertebra D, thus producing an acute kyposis of the 11th and 12th dorsal vertebræ and a lordosis of the lumbar vertebræ. This is a condition of Pott's Disease or caries of the 12th dorsal vertebra. The ankylosis of the 11th and 12th dorsal vertebræ is adaptative, in the fact that it is to help strengthen this weakened link. Lateral views should be taken of all cases where suspected conditions of Pott's Disease or caries are thought to exist.

PART III

X-RAY TUBES AND THEIR ACCESSORIES

There are many kinds of X-Ray tubes in use today, but in our lecture we will consider the four that have proven to be the most practical.

GAS TUBE.

The gas tube has for description the following parts:

1. Bulb.
2. Anode, or positive end.
3. Cathode, or negative end.
4. Auxiliary stem.
5. Assistant anode.
6. Target.

1. The bulb is the large round part of the tube between the anode on one end and the cathode on the other. This bulb contains the target which is in the center.

2. The anode or positive end, is the long narrow stem of the tube, containing a long steel jacket, which extends into the bulb and supports the target, which is placed at the end of it. Extending in from the extreme end of the anode we have a small wire which is attached to the steel jacket and carries the current to the tube. The positive wire is attached to this end.

3. The cathode or negative end, is the large end of the tube. Contained in this end is a steel rod to which is attached a steel jacket. In this jacket is contained a con-

cave aluminum disc, the function of which is to reflect the cathode ray to the target and form the X-Ray. A small wire extends from the termination of the steel rod to the extreme end of the cathode; thus the current is carried back to the machine. The negative wire is attached to this end.

4. The auxiliary stem extends outward from the upper or superior part of the bulb about the center. This auxiliary stem, contains asbestos wool, which is saturated with a gas forming chemical. The end of this stem serves to give attachment to the vacuum regulator wire.

5. The assistant anode is that part of the tube extending outward from the bulb and lying midway between the anode and the auxiliary stem. It contains an aluminum rod, at the end of which is attached a flat aluminum disc.

Extending from the anode to the assistant anode is a small coil wire which serves to carry current from the anode to the assistant anode and thence thru the tube.

The target or anti-cathode, or anode proper, is made up of copper in the center of which is placed a button made of tungsten. This tungsten is about $\frac{5}{8}$ of an inch in diameter and about $\frac{3}{32}$ of an inch in thickness. It is on this button when the Cathode Ray strikes it, that the X-Ray is produced. The target is always placed at an angle of 45 degrees, so that the X-Ray is reflected down upon the patient on the table.

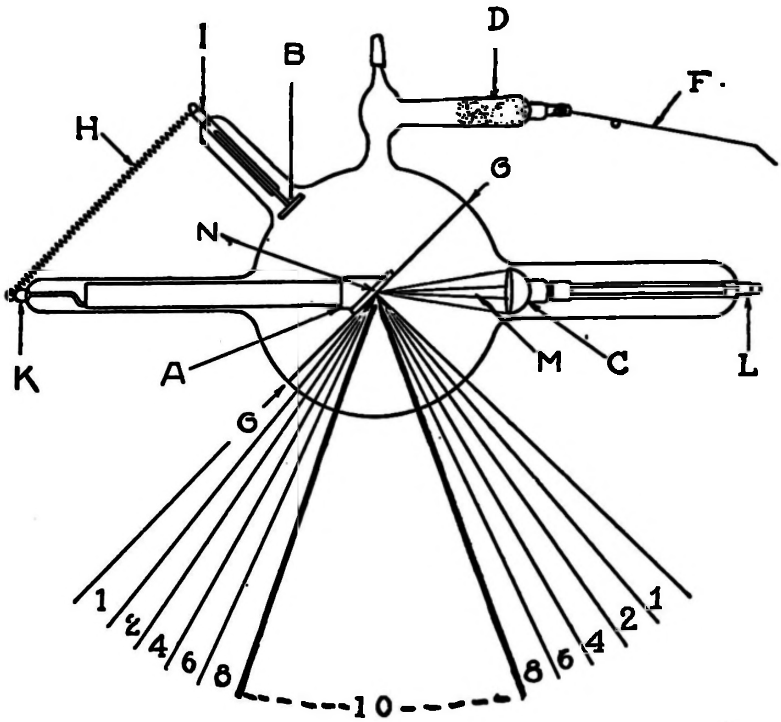


Fig. 26.

DESCRIPTIVE PARTS OF GAS TUBE

A—Anode.
B—Assistant Anode.
C—Cathode.
D—Regulating Chamber.
F—Regulating Adjustor.
G—Hemisphere.
H—Connection Wire.
I—Assistant Anode Cap.
K—Anode Cap.
L—Cathode Cap.
M—Cathode Stream.
N—Focal Point.

The most rapid and effective rays are those reflected at right angles from the cathode stream forming a Focal Point on the anode surface and shown graphically by the

heavy cone "No. 10." The strength of the rays gradually decreases as indicated by the numbers "8-6-4," etc.

TESTING AND OPERATING OF A GAS TUBE

Gas tubes can be purchased that have a high, medium high, medium, medium low and low vacuum.

A high tube and a hard tube are synonymous. A low tube and a soft tube are synonymous.

It is well to have a high, medium and low tube, if one intends to do much X-Ray work; but a medium or medium high tube is used mostly in Spinography.

The life of a high tube for spine work is short compared with that of a medium or medium high tube, for this reason:

The penetration of a high tube is too great for spine work in the majority of cases. In order to reduce a high tube to its proper vacuum or internal resistance for this work, a large quantity of the gas-forming chemical is consumed in the auxiliary stem. This must be done continually before making an exposure to keep the proper vacuum.

Now by constantly doing this, the chemical will soon be used up after which it will be almost impossible to reduce this vacuum and in attempting it the tube is likely to puncture, and as a result, it will be necessary to return the tube to the manufacturer for refilling, or a new regulator, as tube soon becomes useless again unless the regulator is refilled. Re-pumping a tube lowers the efficiency, unless a new cathode is inserted.

A high tube is very seldom used except in such cases as dropsy, real fleshy individuals, or fluoroscopy, or where deep penetration is required.

A medium, or medium-high tube, as stated before, is just of the proper vacuum for spine work and does not necessitate a constant excessive reduction. It will not be necessary to use very much of the chemical in the asbestos wool and as a result, the useful life of the tube will be much longer than that of a high tube.

A low tube, if used with caution, may be used for exposures that do not require any great penetration, such as radiographs of the hand, forearm, foot, ankle and leg, or radiographs of very small children. If a tube of this kind is operated until the bulb is quite warm, many times the vacuum will increase until it is suitable for Spinography, and it will be found a very stable tube, seldom requiring regulating.

The number of milli-ampere seconds and the back-up spark, or degree of penetration, are the first two things to be taken into consideration before making an exposure. Determine the amount of milli-ampere seconds and the back-up spark required, by observing the patient and noting the depth and kind of tissue to be penetrated.

CIRCULATION OF CURRENT THRU THE GAS TUBE

When the X-Ray switch is closed, current from the high tension winding of the coil or transformer passes to the anode end of the tube. The current passes into the anode end and some passes over the small coiled wire to the assistant anode where it enters.

The current flows across and around the bulb of the tube and strikes the cathode disc. This disc is concave and the current is reflected to the target. This reflection from the disc to the target is called the cathode ray. When the cathode ray strike the target it generates the X-Rays.

This target being placed at an angle of 45 degrees, the X-Rays are reflected downward to the object on the table.

The current passes out thru the cathode end over the negative wire to the machine, thus completing the cycle.

HOW TO RAISE THE VACUUM OF A GAS TUBE

Detach the wire from the anode to the assistant anode. Then attach the positive wire to the assistant anode, leaving the negative wire connected to the cathode end. Have the rheostat on button one. Insert the X-Ray switch and allow the current to pass into the tube for 15 or 20 minutes, or until the tube begins to get warm around the cathode disc. Allow the tube to rest for five or six hours. Repeat this operation several times and let the tube rest a few days before using. This method may or may not be successful. If not, the tube must be sent to the manufacturer for repumping.

HYDROGEN X-RAY TUBE

This is another type of an X-Ray tube which is similar in construction and action as the common type of gas tube, with the exception that it has a reducer in place of the assistant anode and a raiser in place of the auxiliary stem, and that it may be raised or lowered in vacuum.

DESCRIPTION

Following is a description and instructions for using this type:

1. To lower the vacuum, pass thru the reducer about 15 milli-amperes, five or ten seconds at a time. Repeat if necessary. Do not use more current; use more time. Always maintain polarity as indicated on the above illustration.

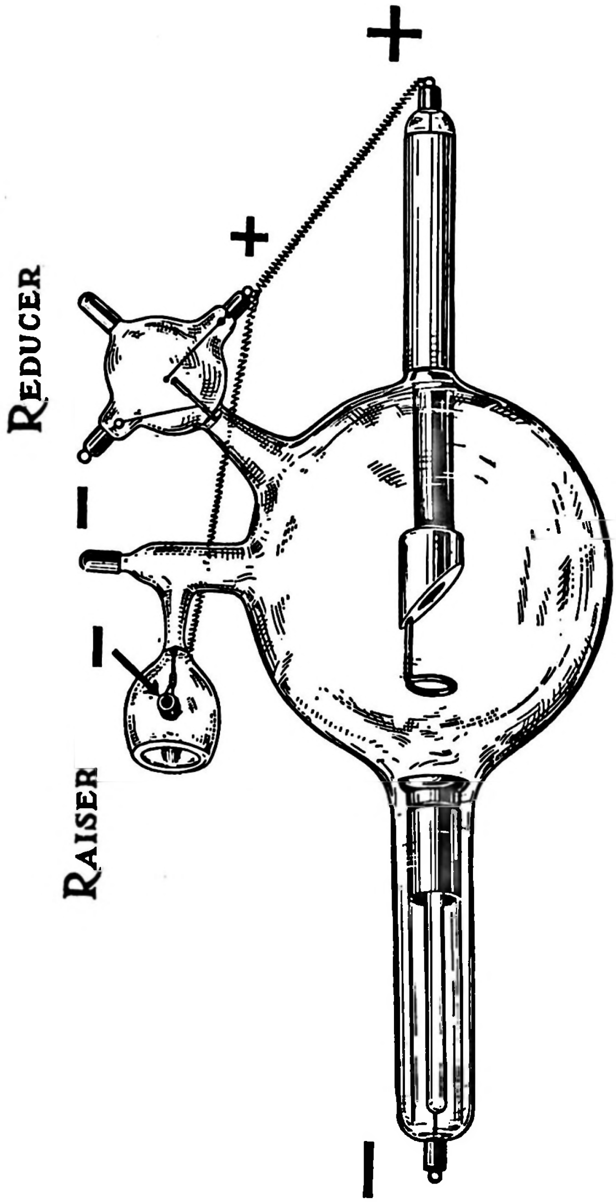
2. To raise the vacuum, pass thru the raiser about 25 milli-amperes (never more than 30 milli-amperes), twenty seconds at a time. If the vacuum is below ⅛ inch, disconnect spiral temporarily from positive (+) terminal of raiser. Connect anode wire to positive (+) terminal of raiser and cathode wire to negative (—) terminal of raiser. Run three minutes with 22 to 25 milli-amperes. Repeat if necessary. Replace spiral.

3. To regulate the tube before making exposure: it should test out at a two inch vacuum with low current (about 5 milli-amperes). This may vary with some machines.

4. The normal tendency of the vacuum is to raise a trifle during the first exposure when the tube is cold. To compensate for this, introduce a little more gas.

5. The focal plate distance given on the index line is about that used in common practice with the conventional cone.

6. 40 M. A. is specified because a medium focus anode will give much more service than with 45 to 50 milli-amperes. Less current can be used with more time provided spark gap is correct.



HYDROGEN TUBE
Fig. 27.

7. **A sharp focus tube** should be limited to **20 milli-amperes** and the time of exposure doubled.

8. Use a **broad focus** tube for extremely **fast exposure** in making stomach and intestinal plates.

9. **Spine** 40x3 means 40 milli-amperes, three (3) seconds or 120 milli-ampere seconds.
   Shoulder 40x1-½ means 40 milli-amperes, one and one-half (1-½) seconds.

10. **Modify exposures:**
    A. Weight of a patient increases the time if the patient weighs more than 150 pounds.
    B. Increase the time if a slow plate is used.
    C. Increase the time if the focal plane distance is more than given on the chart which is supplied with the tube.
    D. Increase the time if more density is desired.
    E. If an intensifying screen is used, cut the time down to about one-third or one-sixth, depending on spark gap and spread of screen.

THE COOLIDGE TUBE

The Coolidge tube has for discription the following parts:

1. Bulb.
2. Anode or positive terminal.
3. Cathode or negative terminal.
4. Target or anti cathode.
5. Tungsten spiral, or filament.

The bulb is the large round part lying between the anode end of the tube and the cathode end of the tube

This bulb contains the target, the cathode disc and the tungsten spiral or filament.

This tube is pumped to an extremely high vacuum, so that no current will flow through the tube, even at extremely high voltage. To provide a path for the current, a spiral filament throws a stream of electrons on to the flat side of the anode. This stream serves as a path for the high tension discharge which generates the X-Ray waves.

The anode or positive end of the tube is the large end of the tube in which is found a steel jacket supporting a

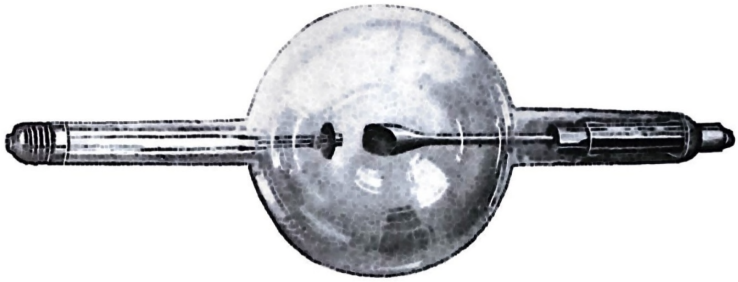


Fig. 28.

long rod of molybdenum. At the end of this rod is the target which is made entirely of tungsten, with a flat side forming the anode, this flat side being set at 45, etc. The positive wire is attached to this end.

The cathode or negative end of the tube is the smaller end. The smaller end of the Coolidge tube is equipped with a threaded cap to which the filament current is conducted from a storage battery, or a low voltage transformer. This cathode consists of a small spiral filament in a cup or bowl-shaped metal sleeve. The filament is set so that the stream

of light, or heat, is focused on the face of the anode. The curvature of the face of the spiral controls the size of the focus from which the rays are projected. The broadest focus not being adapted for radiographic work, but for treatment purposes, as it will not give sharp, clean detail, like the small focus would. The target is found in the center of the bulb. It is made entirely of tungsten and is placed at an angle of 45 degrees so as to direct the rays downward.

The filament current that produces the light or heat is controlled by a separate battery, or a low voltage transformer, which is made especially for Coolidge tube equipments. This current is controlled by a rheostat or control switch, whereby the current in the tungsten filament may be changed at will. This current enters the tube at the negative end.

The amount of current passing to the tungsten filament is governed by the filament control attached to or accompanying the separate transformer. The current is either increased or decreased in the tungsten filament. The brighter the light or the more power passing to the tungsten filament, the lower is the internal resistance of the tube, and the more milli-amperes will flow and the less the spark gap. The machine rheostat should be adjusted to restore the gap.

The dimmer the light, or the less power passing to the tungsten filament the higher is the internal resistance of the tube. This change in the resistance of the tube, as governed by the filament, is due to the quantity of the electrons passing between the cathode and the target.

The more power passing to the tungsten filament, the greater is the activity of these electrons and as a result,

more power is allowed to pass thru the tube and vice-versa, when there is a less amount of current going to the tungsten filament.

The Coolidge tube in general differs from the gas tube in the following ways:

1. It has no auxiliary stem.
2. It has no assistant anode.
3. The cathode disc is flat in some, cup-shaped in others.
4. It is not a gas tube.
5. The absence of the apple green color.
6. The vacuum is 1,000 times greater.
7. The target is all tungsten.
8. No current passes thru the tube unless the tungsten filament is lighted.
9. The resistance is increased or decreased at at will.
10. It must have a separate transformer or battery which carries current to the tungsten filament only.
11. The vacuum never changes.

OPERATION OF A COOLIDGE TUBE

The resistance of this tube can be increased or decreased at will by increasing or decreasing the amount of heat in the tungsten filament. This is governed by the filament control accompanying the separate battery or transformer, which supplies the filament current for this tube.

The more current that is passed into the tungsten

filament the hotter it will be and the more electrons thrown off, and as aresult more current or milli-amperes can pass into the tube. Hence, in order to lower the resistance of the tube it is necessary to increase the amount of heat and light in the tungsten filament.

The less current passing into the tungsten filament the dimmer the light will be and the activity of the electrons decreased. The internal resistance will then be increased and will allow only a very small amount of current or milli-amperes to pass thru the tube. Then, in order to increase the resistance of the tube, decrease the amount of current going to the tungsten filament.

For example, suppose a five-inch back-up and 30 milli-amperes for a certain exposure has been decided upon.

First, after having the tube properly placed and wires properly connected, advance the machine rheostat to a button that you think will give the required 30 milli-amperes and spark gap desired. Place the back-up spark gap at 5½ inches and insert the X-Ray switch. If the flame jumps the gap, it is known that the resistance is too high and must be reduced. Leave the rheostat set on the machine and increase the amount of current going to the tungsten filament. This will lower the resistance. Continue this process until there is no feathery flame at 5½ inches, but a bluish haze or corona shows between the spark gap terminals. If the milli-amperes are found higher than desired, move the machine rheostat handle back one button and reduce the filament current until the blue haze, or corna discharge again appears. Then note the milli-amperes meter reading to see if correct. If not, adjust rheostat again, until the desired milli-amperes and spark gap are secured.

RADIATOR SELF-RECTIFYING TYPE COOLIDGE X-RAY TUBE

This is a new X-Ray tube that was developed during the time that this country was at war and was widely used in army X-Ray service, both at home and in the field. This tube differs from the Coolidge tube previously described, in the fact that the bulb is much smaller and the target, or anti-cathode, is made of copper with a tungsten button in the center of the target face. Connected with this target

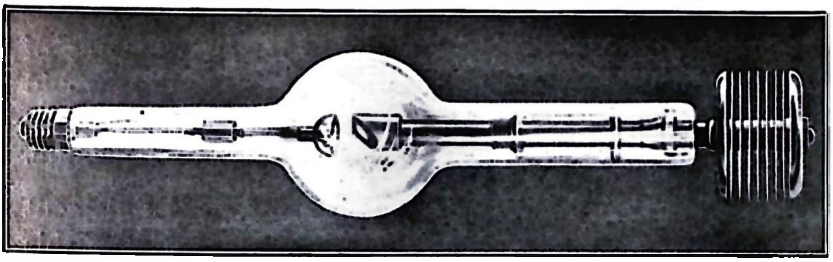


Fig. 29.

is a long coper rod that extends out through the anode, or positive end, of the tube. Attached to this copper rod there is a steel radiator, consisting of many disks.

The cathode end of this tube contains the connecting wires and the cathode with the tungsten filament, or spiral, within its center. This cathode is a hemispherical bowl while in the larger types of Coolidge tubes it is flat. The reason for the bulb of this tube being smaller is that the metal parts inside of the tube do not become red hot as they do in the other Coolidge tube, and the heat that is generated is taken up by the radiator, this keeping the glass of the tube from getting hot.

These tubes are made in several capacities, the 10 milli-ampere tube being made with a fine focus, giving very sharp detail. The milli-amperes used in this tube must always be carefully watched as it is made to receive ten milli-amperes only. It can be used on a coil or transformer without a motor and rectifying disc, as it will rectify the alternating current when using only ten milli-amperes. Should anything go wrong with your motor on the ordinary type interrupterless machine so that you cannot use it, you may still use this tube by having the disc placed so that they will make a connection.

Being unable to use more than ten milli-amperes of current through this tube, the time of our exposures would be worked out by using your milli-ampere second scale. Using this tube in this manner, the life of it is indefinite.

The resistance of this tube is regulated by the filament control the same as in the Coolidge tube preceding this description.

This type of tube is also made to handle large currents, depending on the size of the focal point. The 30 milli-ampere type radiator tube has a larger focus than the 10 milli-ampere type, but it is a smaller focus than the fine focus Standard type Coolidge tube, and, therefore, gives better detail than the latter, and also radiates the heat faster and will not pit the target or anode as the older style tube does.

PART IV

X-RAY EQUIPMENT

THE INTERRUPTERLESS MACHINE

To attempt to thoroughly cover all the electrical apparatus in connection with all types, sizes, etc. of X-Ray Equipment would require volumes and impose upon the reader an endless task of endeavor to properly interpret needless technicalities. The sole intent of the following is to give a plain, concise, non-technical explanation of the most important parts and points in connection with the electrical operation of the accepted standard in X-Ray apparatus namely,—the Interrupterless type.

The Interrupterless type of equipment has for description the following important parts and a non-technical explanation will follow each part named:

TRANSFORMER

The purpose of the transformer is to raise the potential or voltage from 110 to 220, at which voltage the circuit enters the building, to the required voltage for X-Ray tube operation. This will vary with the size and type of equipment, but usually will approximate 100,000 volts or over.

The design of the transformer is extremely important, not from point of capacity and efficiency, but from point of maintained capacity under actual operation. If for instance the transformer maintained maximum voltage at practically no load, but showed a decided drop in potential

Fig. 30.

The Interrupterless Machine

or voltage under loaded condition, this would decrease the penetration of the X-Rays, because of the decreased voltage at the tube terminals. Transformers for stepping up low tension alternating current should be of the closed core type, i. e. the magnetic circuit is not broken by an air gap. In other words the core of the transformer should be continuous and of a rectangular shape. The material used in building up the core should be special transformer steel and rigidly clamped so there will be no vibration or chattering of any part of the core, due to magnetic influence under actual operation. The part of the core upon which the primary winding is placed should be thoroughly insulated and in placing the secondary winding, which is the high tension or high voltage winding, the very best insulating material should be used, such as macanite, which will separate and insulate the primary from the secondary winding. A transformer said to have 110,000 volts will produce a ten inch flame discharge across its terminals. The following example will give you some idea of the design of a transformer and the number of turns of wire required for a certain given voltage.

Assuming we have a secondary with 55,000 turns of wire and we wish to produce a ten inch spark. To produce this spark requires 110,000 volts. The number of turns of wire for the primary will therefore have to be 55,000 divided by 110,000 multiplied by 220 equals 110 turns. A simple illustration of the above example would be, for instance,—assume 1000 turns on the transformer core on the secondary side with 100 turns on the primary side. If 100 volts were passed through the 100 turns side there would be impressed across the terminals of the 1000 turn side 1000 volts or approximately ten times the voltage of the 100 turn

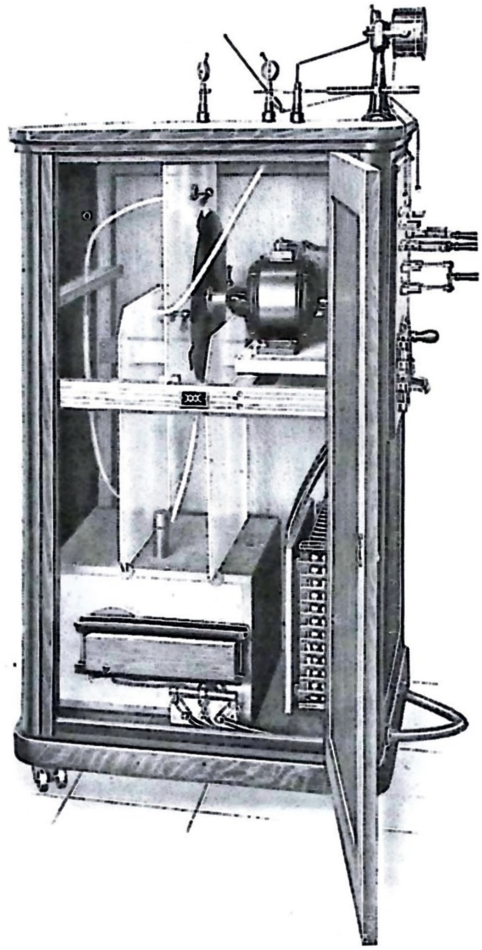


Fig. 31.

Rear View of the Interrupterless Machine

side. The voltage of a transformer can be calculated by the direct ratio of difference between its primary and secondary in number of turns, as for previous simple example.—the number of turns on the one side was 100, while the number of turns on the secondary was 1000. This then gives us a ratio of 10 to 1. If then 100 volts were passed through the 100 turn side you would have impressed upon the 1000 turn side 10 times 100 or 1000 volts. This essential feature then in connection with the transformer is the ability of same to retain approximate maximum voltage from zero load to maximum load. Also close proximity of the primary and secondary windings as well as a closed core. A secondary should be built in sections so that if repair is necessary, this can be done without practically destroying the entire winding.

RHEOSTAT

The purpose of the Rheostat is to control the amount of current which passes into or through the tube. In explanation of the working principles of the rheostat it can be likened to a valve in a water pipe,—as the valve is opened in the pipe, less resistance is offered and more water passes through. Likewise of the rheostat, the less resisting material you place in a circuit the easier the current can pass through, the rheostat being placed in one main lead passing to the transformer acting as a valve. If the rheostat handle is placed on the weakest button the current is forced to pass through a good many turns made up in coil form of German Silver or other resistance wire. Most manufacturers use a tinned iron wire, which offers a high resistance and naturally retards the current. If the rheostat is advanced, less of this resisting material is in this circuit. As an

example,—we might assume 1000 feet of German Silver wire inserted in the circuit between the transformer and the incoming main leads. Suppose as an example only, that this reduced the current 50% and that this 1000 feet was made up in ten coils spirally wound on asbestos insulating material in a vertical position in 100-foot lengths. Now if the circuit was forced to pass through the entire 1000 feet, as has been stated before, as an example only, the circuit would be reduced 50%. Now supposing by a moving contact we could shorten this resistance wire 100 feet, the circuit would now pass through 900 feet only, the resistance of 900 feet not being as great as 1000 feet, the current in your tube would increase slightly. Suppose you advanced your rheostat to the 5th button, you have now cut out one-half or 500 feet of your resistance and you will increase your current in your tube in proportion.

The essential features in the design of a rheostat are its ability to withstand a certain given current on a certain contact over a reasonable length of time without undue heating. Also the gradations should be uniform and not too irregular so that the current in the tube will be increased gradually as the rheostat is advanced.

MOTOR

The purpose of the motor in connection with the Interrupterless Machine is to revolve the mica disc. A properly designed motor is one which will keep in absolute step or synchronism with the incoming circuit. It is of course assumed on a 60 cycle system that the alternations will be 7200 per minute, but it is a known electrical fact

that it is impossible to maintain an absolute frequency, consequently the operation of the motor must be flexible, that is if the frequency or alternations rise or fall the motor will correspondingly rise and fall and thereby keep in absolute step or synchronism with the circuit.

MICA DISC OR RECTIFYING COMMUTATOR

The purpose of the mica disc or rectifying commutator, which is attached to the motor shaft, is that of commutating or rectifying the alternating current which has been raised from 110 or 220 to 100,000 volts or more to a direct or uni-directional current. In other words a current which is passing at all times in the same direction with no reversals.

The design of a rectifying commutator or mica disc is a very important one. It has been found, through experience, that it is possible to commutate too much, or in other words, make contact too long, in this way passing current into the tube which was objectionable. A disc which is properly designed should commutate or rectify approximately 15% of the crest of the alternating wave, as anything more than 15% approximately has a detrimental effect upon the penetration as well as the life of the tube. You will note in all Interrupterless type of machines two connections passing from high voltage side of the transformer to the brush holders, which make contact with the revolving disc or commutator. You will also note two leads of wire passing from the brush holders, which make contact with the disc, to the terminals on the top of the machine, this making four contacts on the disc in all. Supposing we assume the left hand wire on the transformer, as you are

looking into the case, to be negative, the right hand wire on the transformer to be positive. If the current maintained and would not reverse, such as is the case in direct current, it would not be necessary to reverse the leads to the top of the machine. Bear in mind this condition exists only for one seventy-two-hundredth part of a minute, for the next seventy-two-hundredths part of a minute the wire that was positive is now negative and the one that was negative is now positive, which would mean if the disc did not revolve and change contacts we would have a reversal of current to the top of the machine and into the tube. But during the time the current reversed, so also did the position of the disc, so now the connections which did exist one seventy two hundredth part of a minute have been reversed, so that the positive current is taken to the positive side of the machine as well as the negative current being taken to the negative side of the machine. The next seventy two hundredths part of a minute the change takes place again in the current. So also has the disc or commutator changed because of the rotation of the motor, and this operation is continuous, keeping the positive wire to the positive side of the machine when it is positive and keeping the negative wire to the negative side of the machine when it is negative, and when the change takes place in the current, the disc also changes, reversing the connection and keeping the current in the proper direction at all times into the tube.

MILLI-AMMETER

The purpose of this instrument is to give an accurate measurement of the current passing through the X-ray tube. The essential principles in its construction are ap-

proximately the same as any ordinary ammeter. The reason why the instrument on the X-ray machine is called milli-ammeter is because it registers in one one-thousandths of an ampere in place of one ampere, thereby giving you a finer gradation and a more accurate reading. It is of course essential that the instrument be accurate, and in practically all cases the instruments are thoroughly tested and found to be accurate and reliable before being placed on the equipment.

POLARITY INDICATOR

The purpose of the polarity indicator is to indicate the direction of the current and in the majority of cases is so placed on the switch board that if the needle of the instrument swings to the right, the pole changer switch is closed to the right. If on the other hand the instrument needle swings to the left, the pole changer switch is closed to the left. Through the use of the polarity indicator, the operator is absolutely certain that the current will pass through the tube in the proper direction.

VACUUM REGULATOR

The purpose of the vacuum regulator is to have a means by which you can reduce the internal resistance of an X-Ray tube, without leaving the machine. This is done by sliding a rod or pulling a movable contact over to the negative terminal on top of machine, in this way passing a current through the vacuum regulator and the reel and wire leading therefrom, to the regulating chamber on the X-Ray tube, the current then passing through the asbestos wick, which is filled with sodium hydrate or some other chemical which, when an electric spark or current is passed through,

gives off a gas. This gas reduces the resistance between the Anode and the Cathode terminals of the X-Ray tube, thereby decreasing its resistance as well as its penetration, or increasing the amount of current that can be passed through the tube at a given potential or voltage, as may be desired.

BACK-UP SPARK TESTS

The purpose of this test is to ascertain the penetration of the rays being generated in the tube at the time. The back-up test or spark gap, which has a movable rod wherein you can vary the distance between these points from approximately 2½ to 7 or 8 inches. In the majority of all osseous work such as spinography, experience has proven that a 5-inch back-up is best, while a tube of a 4-inch back-up would be much the best if you were taking a spinograph of a child; also a tube of a 6-inch back-up would be best if you were taking a spinograph of a very heavy patient.

In testing a tube by the back-up method. First we should understand something of the "why" of the test, otherwise we are going into our work blindly. It seems to have been the opinion of some, until experience has taught them differently, that the spark gap has something to do with the operation of the machine proper as well as of the tube. Permit me to point out this is not true. The spark gap or back-up is a means by which the operator can ascertain the condition of the tube, whether it is too high, commonly spoken of as "hard," or whether the tube is too low, commonly spoken of as being soft. The procedure which would be necessary for testing a tube follows: Assuming that we were about to take a plate of an individual requiring a 5-inch back-up,—advance your rheostat to a

point which would give you approximately 25 M. A. set your spark gap at 5½ inches. See that your tube is properly connected, omitting the connection to the reducing chamber or auxiliary stem, close and open your X-ray switch quickly. If the current jumps across or bridges the spark gap, return the rheostat to button No. 1. Push the reducing or vacuum regulator apparatus so that it makes contact with the negative lead of the machine connecting your middle lead with the auxiliary or reducing chamber of the tube. See that your rheostat handle is returned to button No. 1 and close and open your X-ray switch very quickly, then disconnect your middle reel from the auxiliary stem or reducing chamber of the tube pulling back your vacuum regulator apparatus on top of machine, return your rheostat to the former point, and test again for gap. See that your spark gap is set at 5½ and close and open your X-ray switch again quickly. If it still jumps across, repeat the same procedure, which has been above explained. After doing same, disconnect your middle reel, return your vacuum regulator apparatus to its proper position, advancing the rheostat to the former point and again close and open your X-ray switch quickly. Now if the current does not jump across or bridge the spark gap, move the spark gap one-half inch closer to see that you have not reduced the tube too much. Now if it bridges the gap or back-up at 5 inches and does not bridge the gap at 5½ inches, your tube now stands at a back-up of between 5 and 5½ inches. Before starting your exposure, you should open your spark gap half an inch greater distance than the actual jumping distance of the current, as tested, and proceed with your exposure as follows. Supposing, as per Milli-Ampere Exposure table,

which will be found elsewhere, you find that a 200 Milli-Ampere second exposure was necessary,—you would proceed as follows: Close your switch for one second, noting how much current is passing through the tube, then open the switch for a second or so to allow tube to cool, then close your switch again noting the current, open again after one second, and as per example as follows. Supposing 20 Milli-Amperes were passing through the instrument, every second of time will be equivalent to 20 Milli-Amperes adding each consecutive second until the sum total is 200, which means 200 milli-ampere seconds. Test your machine out thoroughly when first installed, to be certain that the spark gap does not decrease rapidly while exposing, due to heating of the rheostat. If you find the regulation is such that the gap decreases, say from 5 inches to 4 or 4½, you will have to increase the total number of milli-ampere seconds from 20 to 40% over that given in the table, or else start out with ½-inch greater gap than indicated in the average exposure table. This is quite important, as many machines will not maintain the same spark gap throughout an 8 or 10-second exposure, especially if heavy currents are used.

MILLI-AMPERE SECONDS

(M. A. S.) The term Milli-Ampere Seconds means the product of the current passing through the instrument into the tube multiplied by the time in seconds the time it is used. Example follows: Supposing one milli-ampere was passing through the tube for 200 seconds, either continuously or intermittently the product of the seconds times the current would be 200 milli-ampere seconds. Another example,—For instance 20 M. A. was passing through the tube and this amount of current was used either continu-

ously or intermittently for 10 seconds the product would be 10 seconds times 20 M. A., or 200 M. A. S.

The point I wish to convey in connection with the M. A. S. exposure system is this. Do not get the idea that you must know the number of seconds required for an exposure, but you must know the number of M. A. S. or total amount of current that is necessary to produce a certain negative. All of this has been figured in table form, wherein you can compare the thickness of any part of the individual with the table and find the required M. A. S. for the given thickness. Now, it makes no difference as to the time that is consumed in the exposure, but the most important feature is the total amount of current over a given time, consequently in figuring your exposure be certain that you time your individual seconds correctly, and when the product of the current (in milli-amperes), which is passing through the instrument, multiplied by the number of seconds equals the total M. A. S. required, per table found elsewhere, your exposure is completed.

An approximate accurate system of testing a tube as to its condition is to note the amount of current passing through the tube on rheostat button No. 1, using the low scale of the milli-ampere meter, if it has two scales. A tube of the proper vacuum will allow the passage of approximately 3.4 to 3.6 M. A. and a tube which takes this current on button No. 1 will be of the proper back-up when used with a current of 20 to 25 M. A. If when testing a tube in this way, you find the tube will not take this amount of current, the tube should be reduced slightly and the test repeated. . If the current is still under 3.4 to 3.6 on button No. 1 the tube is still too high, and should

be reduced again; in other words, a tube which does not take from 3.4 to 3.6 M. A. on button No. 1, should be reduced until it does take this amount of current.

In the foregoing descriptions and explanations, no attempt has been made to cover each and every operation exhaustively, from a technical standpoint. In fact the opposite has been done. Technicalities have been eliminated and only the actual necessary terms used in connection with the apparatus. It is practically impossible to give a set of instructions which will cover any and all X-ray equipment, even though they be of the same type and of the same manufacture, because of the fact that switches, rheostats, regulating apparatus are differently placed and have a tendency to confuse the operator until by actual demonstration and operation they have found out what each and every part is and its purpose. If, however, even a small amount of information is gleaned from the foregoing, the writer will feel amply repaid for his endeavor.

DONT'S FOR INTERRUPTERLESS MACHINE

1. Don't connect middle reel to chemical reducer of tube except when reducing tube.
2. Don't have rheostat lever beyond first button when reducing tube.
3. Don't use tube for radiography of heavy parts if it takes more than 5 M. A. on first button.
4. Don't reduce tube so that it will take more than than 5 M. A. or show cathode (violet) stream on first button.
5. Don't reduce tube unless it takes less than 4 M. A. on the first button for radiography.

6. Don't take radiograph with heavy current without changing to high scale on meter.
7. Don't have negative wire to cathode closer than 5 inches from chemical reducer of tube (perpendicular distance).
8. Don't close "pole changer" switch unless polarity indicator indicates correctly.
9. Don't clean commutator or slip rings of synchronous motor or rotary converter with emery paper or cloth. Use fine sand paper only.

TUBE DISTANCE

The spine has been, and still is one of the hardest regions of the body to radiograph, so that all parts and shadows of the vertebrae are clearly outlined.

Spinographic technic has been our specialty from the time we first used an X-Ray equipment; by making it our speciality we feel that we have improved and developed this part of X-Ray work into an art all its own.

The tube distance plays a very important part in taking good spinographs as it is our aim to have the spine stand out sharp and clearly on the plate, that it may be more easily read from a Chiropractic standpoint.

For this reason we must consider some of the laws of physics that have to do with relation of intensity of light to the distance. It is self-evident that any light is dimmer the farther away it is. This is a very definite law and in the study of physics it is known as the law of Jarvis Squares.

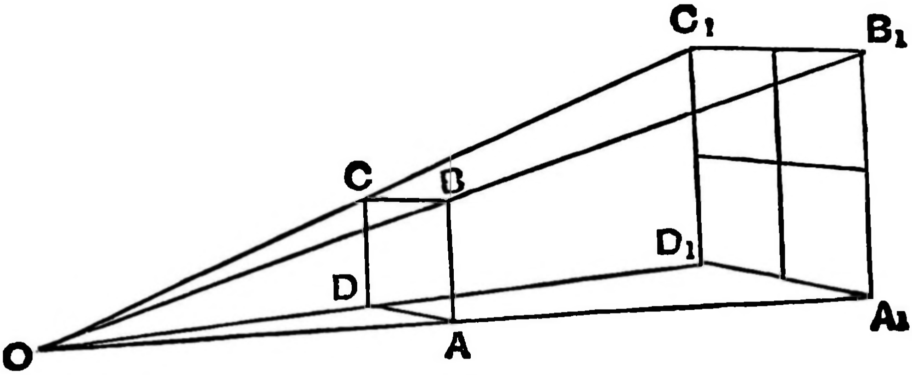


Fig. 32.

In the above diagram suppose O is a candle or other source of light and A, B, C, D, is an opening one foot away from O. Letters A_1, B_1, C_1, D_1, represents a screen two feet from O. It is evident that the amount of light passing thru A, B, C, D, covers four times the area when it reaches the screen two feet away.

The law is generally stated that the intensity of a source of light varies inversely with the square of the distance; in the above diagram it would take four times as long for a given amount of light to reach a square inch of area on the screen as it would a square inch on A, B, C, and D.

This same law is applicable to the X-Ray. We must, however, consider the length of the first exposure, and the distance of the target from the plate. We must then consider the distance of the target from the plate in the second exposure and from this basis must compute the length of time required.

Assume that in the first instance the distance of the target from the plate is 12 inches and the exposure is for

3 seconds. In the second instance the distance of the target from the plate is 24 inches and the length of time must be computed.

The foregoing assumes that the tube conditions are the same.

Let X represent the time for the second exposure.

$$\frac{3}{X} = \frac{12^2}{24^2}$$

$$\frac{3}{X} = \frac{144}{576}$$

$$\frac{3}{X} = \frac{1}{4}$$

Multiplying the means by the extremes we have

$$1xX = 3x4$$

$1X = 12$ seconds as the length of time for the second exposure.

Example. Under certain tube conditions an exposure of 10 seconds is required with the distance at 24 inches. What would be the time of exposure if the distance were 18 inches?

Let Z represent the length of time for the second exposure.

$$\frac{10}{Z} = \frac{24^2}{18^2}$$

$$\frac{10}{Z} = \frac{576}{324}$$

$$\frac{10}{Z} = \frac{16}{9}$$

Multiplying the means by the extremes we have

$$16xZ = 10x9$$
$$16Z = 90$$

$Z = 5\frac{5}{8}$ seconds as the length of time for the second exposure.

Under certain tube conditions an expsoure of 10 seconds is required at a distance of 26 inches. What would be the time of the exposure if the distance were 15 inches?

Let Y represent the length of time for the second exposure.

$$\frac{10}{Y} = \frac{25}{15}$$

$$\frac{10}{Y} = \frac{625}{225}$$

$$\frac{10}{Y} = \frac{25}{9}$$

Multiplying the means by the extremes we have

$$25xY = 10x9$$
$$25Y = 90$$

$Y = 3\frac{3}{5}$ seconds exposure for the second distance of 15 inches.

It is well in comparing times of exposures at different distances, to take only such distances as have a simple relation to each other. In this way the problem can be

solved very quickly, as indicated above. In other cases the method is the same but requires more calculation.

Example. Under certain tube conditions if an exposure of six seconds is required at a distance of 17 inches, what exposure would be required at a distance of 23 inches?

Let W represent the time of the second exposure.

$$\frac{6}{W} = \frac{17^2}{23^2}$$

$$\frac{6}{W} = \frac{289}{529}$$

Multiplying the means by the extremes we have

$$289 \text{x} W = 529 \text{x} 6$$

$$289W = 3174$$

$W = 10^{284}/_{289}$ or very nearly 11 seconds as the time for the second exposure.

For illustration say the tube distance for a certain exposure was 18 inches and required 200 M. A. S. If the tube distance were increased to 36 inches or twice the distance from the plate, the exposure, instead of being 200 M. A. S., would be 4x200 M. A. S., or 800 M. A. S. If the distance is 27 inches instead of 18 inches, the exposure will be 2 times 200 M. A. S. or 400 M. A. S., the plate being twice as far away from the tube focus as given in the preceding scale, the exposure will be 4 times as long. The exposure in which the tube distance varies several inches can be determined from the preceding instructions.

Having made spinography our special study I submit the following tables, which applies to patients weighing 150 pounds.

MILLI-AMPERE SECOND EXPOSURE TABLE

Thickness of Object	Back-Up	Tube Distance	M. A. Seconds
2 inches	3 inches	18 inches	10
2½ inches	3 inches	18 inches	18
3 inches	3½ inches	18 inches	24
3½ inches	3¾ or 4 inches	18 inches	32
4 inches	4 inches	18 inches	40
4½ inches	4½ inches	18 inches	48
5 inches	4½ inches	18 inches	64
5½ inches	4½ inches	18 inches	80
6 inches	5 inches	18 inches	175
6½ inches	5 inches	18 inches	200
7 inches	5 inches	19 inches	225
7½ inches	5½ inches	19 inches	240
8 inches	5½ inches	20 inches	250
8½ inches	5½ inches	20 inches	256
9 inches	5½ or 6 inches	22 inches	296
9½ inches	6 inches	22 inches	340
10 inches	6 inches	22 inches	400
10½ inches	6 or 6½ inches	22½ inches	460

PARTS OF THE BODY EXPOSURE TABLE

Parts	Back-Up	Time	Tube Dist'ce	Milli-Amps.
Arm and elbow	5 inches	1 sec.	16 in.	25
Forearm and wrist	5 inches	1 sec.	16 in.	25
Fingers and toes	4 inches	1 flash	16 in.	20
Foot	4 inches	1 flash	16 in.	20
Ankle	4 inches	1 sec.	16 in.	25
Leg	5 inches	1 sec.	16 in.	25
Knee	6 inches	1½ secs.	18 in.	30
Femur	6 inches	1½ secs.	18 in.	30
Pelvis	6½ inches	2½ secs.	24 in.	40
Hip Joint	6 inches	2 secs.	20 in.	40
Bladder	5 inches	2 sec.—compression		40
Ureters	5 inches	4½ sec.—compression		40

Kidneys ....5 inches	$4\frac{1}{2}$ sec.—compression			40
Intestines ....$6\frac{1}{2}$ inches	1	sec.	25 in.	60
Stomach ....6 inches	1	sec.	25 in.	60
Chest ....6 inches	1	flash	27 in.	50
Shoulders ....6 inches	$2\frac{1}{2}$	sec.	20 in.	35
Head—lateral view $6\frac{1}{2}$ inches	3 sec.—compression			40

SPINOGRAPHIC EXPOSURE TABLE

Parts to Be Spinographed	Back-Up	Tube Distance	Milli-ampere Second
Lumbar Spine	5 inch	24 inches	200 to 250
Lower Dorsal Spine	5 inch	24 inches	250 to 300
Upper Dorsal	5 inch	24 inches	180 to 200
Lower Cervical Spine	5 inch	24 inches	180 to 200
Atlas and Axis	5 inch	18 inches	100 to 120
Lateral View Cervical	5 inch	24 inches	100 to 120
Lateral View Dorsal	6 inch	compression	500 to 600
Lateral View Lumbar	6 inch	compression	500 to 600

The operator must take into consideration that all patients weighing around 150 pounds are not built along the same physical proportions. Some have larger chest development and are more muscular, while others have smaller chest development and a greater development of the abdomen. It is then that you must use your judgment in either increasing or decreasing the amount of milli-ampere seconds. In the preceding tables you will notice that I present one with the thickness of objects, back-up, tube distance and milli-ampere seconds, while in the other I have named the parts to be taken, giving the back-up, the time in seconds, the tube distance and milli-amperes. Multiply the milli-amperes by the time in seconds to obtain the amount of milli-ampere seconds given.

You will notice that I have mentioned very little about compression. Using compression means the bringing of

the cylinder into contact with the abdominal region and pressing it down upon the patient just as tightly as they can endure it. This method is used by many operators in taking radiographs of the spine, while I only use it in heavy individuals.

I have found from experience that a 24-inch distance from target to plate gives the best detail, even tho it may take a few seconds longer to make the exposure.

PART V

THE PLACING OF THE PATIENT AND PLATE

The patient is prepared for a spinograph exposure the same as for palpation. Care should be taken that no pins. buttons, metals, or any other objects that offer resistance to the penetration of the X-Rays, are in the direct path of same, for the shadow may be reflected upon the spinous processes or other parts of the vertebræ and thereby cause difficulty in the correct reading of the plate.

In taking an exposure of the entire spine, four plates should be used. In using three plates, the mouth will have to be opened for the atlas and axis exposure and the rays will have to penetrate the jaws; as a result, there will be difficulty in reading the plate from the third to the sixth cervical vertebræ, as the shadow of the jaw will practically cover this region. A 5" x 7" plate should be used for atlas and axis alone. The mouth will then be closed for the exposure from the third cervical downward. 8" x 10" are most commonly used for other parts of spine work.

It is advisable to palpate each case before making an exposure so as to be absolutely correct in placing the plate, but the rules given later for placing the plates apply to the majority of cases.

The following rules apply to spinography in general:

1. **Always** have the spine as near the center of the plate as possible.

2. **Always** place a marker in the upper right hand

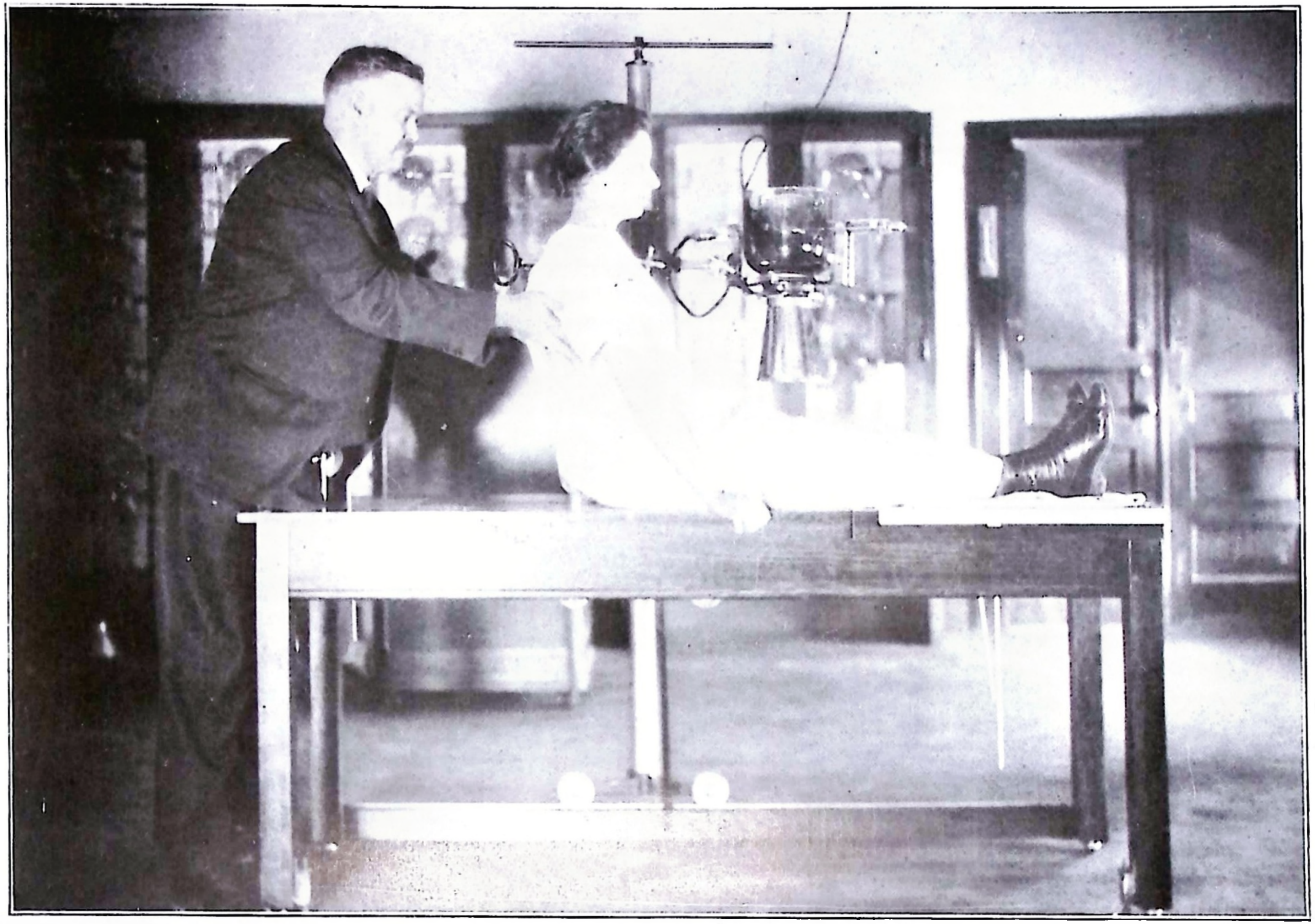


Figure 33—Showing First Position Assumed by Patient When Being Placed Upon the Table for a Spinograph.

corner so that when the plate is developed and ready for reading the marker can be seen from the glazed side in the upper right hand corner.

3. **Always** place the plate for exposure with the emulsion side up (except when using an intensifying screen).

4. **Always** center tube directly over the plate.

5. **Always** have the patient assume a sitting posture first. Next place the plate and take the patient by the shoulders, having patient place the full weight on operator's hands and thereby help patient assume the recumbent position. If plate is not placed properly, which is determined by palpation, have the patient rise again and move the plate to the exact place. Have patient lie down and palpate again to see if plate is properly placed. If not, repeat the process until properly adjusted.

6. **Always** stand at the patient's head and look down over the body to see that he is lying perfectly straight.

7. **Always** see that the upper and lower edges of the plate are at right angles with the axis of the body.

After the plate and patient are properly placed, proceed according to the following instructions:

Whether the lumbar or the dorsal plate should be taken first in taking the entire spine all depends upon the size, weight, etc. of the patient. But the part requiring your greatest penetration should be exposed first, for the following reason:

The tube should be properly adjusted, i.e., of the proper vacuum to make a certain exposure. Then take a lumbar

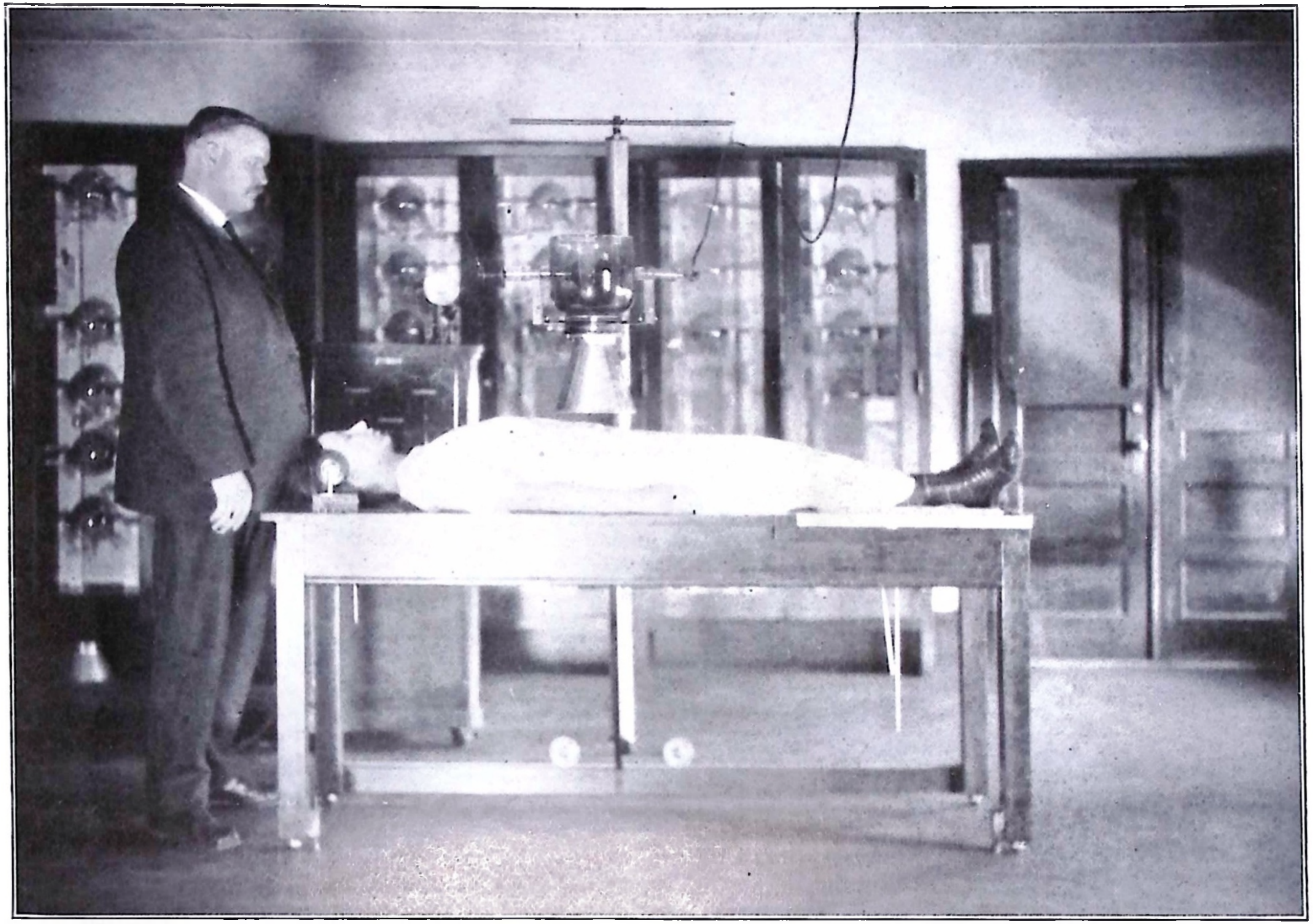


Figure 34—Showing Second Position of Patient with the Operator Standing at the Patient's Head to See that They Are in Perfect Alignment.

plate after deciding that it shall be the first one taken. By running current thru the tube in making the exposure, the tube is continually lowering and by the time the exposure is made the tube is not of the same vacuum, but lower in resistance. The next exposure will not require as much penetration and as a result the tube will probably be of the proper vacuum. By the time the second exposure is made, the tube has again lowered, and then having a cervical exposure to make, the tube will be of the right vacuum. This applies to the gas tube only.

Have the patient sit on the table, in the center, with legs extended. Now place the plate for the **lumbar exposure.** The plate should be placed so that the lower edge of the same will be approximately two inches below the superior crest of the ilium.

For the **dorsal exposure** place the plate 3 to 4 inches, which is determined by palpation, above the superior crest of the ilium. This will give a reading of the 12th dorsal and upward to about the 5th dorsal vertebra.

For the **cervical exposure** (anterior-posterior) from the third cervical downward, place the superior edge of the plate even with the lower edge of the lobe of the ear. This will cover approximately from the 3rd cervical to the 5th or 6th dorsal vertebræ. Have the patient raise the chin so as to avoid interference with the passage of the X-Ray and thereby eliminate all difficulty in reading.

By having the head placed so that the X-Ray will pass thru directly from one side to the other, this will be avoided.

For the **atlas and axis** (anterior-posterior) have the chin on a level with the forehead and have the patient open

the mouth as wide as possible. It would be well to place something between the teeth so as to keep the mouth open continually until the exposure is made and avoiding a possible chance of the patient closing the mouth and spoiling the plate. Have the center of the plate even with the lobe of the ear.

In taking an exposure to decide anteriority or posteriority of an atlas the head should be placed so that the rays will pass thru laterally and not at an angle; for when the head is placed at an angle the ramus of the jaw will obliterate the anterior portion of the atlas and thereby cause difficulty in reading.

For a lateral exposure of the cervical region have patient sit in his normal position.

The foramina in the cervical region emit anterior-laterally at an angle of about 45 degrees and not straight laterally. If a good outline and shape of the foramina is desired in this region, place the patient at such an angle that the foramina are on a plane with the plate and center the tube directly over it. This will assist greatly in making a correct reading.

In taking a plate from the 1st dorsal vertebra down, have the superior edge of the plate visible immediately above the shoulders.

For the sacro-iliac articulation, have the superior border of the plate slightly above the superior crest of the ilium.

ROENTGENOGRAMS OF OTHER OSSEOUS STRUCTURES

In making exposures of any of the osseous structures of the body, it is merely a question of having everything centered properly; that is, have the plate under the part to be exposed and the tube centered directly over the same. Always have the part exposed as near the plate as possible and then determine your degree of penetration and exposure, according to the depth and kind of tissue to be penetrated, as given in the scale earlier in this book.

The reason for having the object to be exposed as near the plate as possible, is that more detail can be obtained. For example, hold an object such as a pencil, under the ordinary light with a table beneath. The nearer the pencil is to the table, the better is the outline of the shadow. In taking pictures of the extremities, it is best to make an exposure of both so that we may have the normal to compare with the abnormal.

Thus with the foregoing instructions properly applied, any of the osseous structures can be properly roentgenographed. There are several exceptions to the preceding scale, which will not be described.

BONES OF THE SKULL AND FACE

These exposures require a greater penetration, for the reason that bones of the head are hard to penetrate. But always have the part to be exposed nearest the plate and apply the following rule in the average case.

Anterior-posterior or posterior-anterior view. Back-up 6½ inches milli-amperes 200. Distance from the target to the plate should be 19 inches.

Lateral view. Back-up 6 inches. Milli-ampere seconds 160. Distance from the target to the plate should be 18 inches.

X-RAY DENTAL WORK

The demand for dental work is increasing rapidly each day. All doubtful cases are referred to the X-Ray by leading dentists. For instance, if the dentist wants to know whether his filling has been made properly; if there is any pus formation at the roots; or if there is some other abnormal condition existing that cannot be detected by ordinary means, he can determine it by having these teeth roentgenographed.

The majority of the films used for this work are 1½x1¼ inches in size. There are several kinds of films used for dental work, such as—

1. Slow film.
2. Fast film.
3. Extra fast film.

The slow film will require a much longer exposure than the extra fast film. In using the fast film, the exposure is from 40 to 60 milli-ampere seconds, at a tube distance of 18 inches.

The back-up spark varies, as some teeth are harder to penetrate than others, especially the molars. A back-up of 5 inches will take the molars using from 80 to 90 milli-ampere seconds with the slow-film—from 60 to 80 milli-ampere seconds for the other teeth using the slow film as more detail can be obtained. This rule applies to the average individual.

The film is placed next the lingual side of the teeth and held firmly. A film holder for this purpose may be used. The film should be placed upward as far as possible so as to get the roots of the teeth and the tube placed at right angles with the film.

Two or three teeth can be roentgenographed on one film. To take the entire set, ten films are required, five above and five below. Have the patient lying or sitting. The former is preferable as the patient is not as likely to move.

PATELLA, OR KNEE CAP

To determine a dislocation of the patella, take a lateral view. For a fracture, take a posterior-anterior view.

THE STERNUM

In roentgenographing the sternum, the patient cannot lie exactly prone, as the spine is immediately above the sternum. Thus, in order to expose the sternum properly and get a clear outline the patient is placed on the table with one side of the body raised, so that the spine is not in the direct path of the rays passing to the sternum. Have the tube centered directly over the sternum.

Or, if the patient lies directly in the prone position, place the tube 1½ inches to the left or right of the median line and tip it so that the X-Rays will pass on directly to the sternum.

These exposures will displace the normal outline and contour of the sternum, but the operator will be able to detect any abnormal condition of it such as fractures, exostoses, etc.

The exposure (milli-ampere seconds and back-up) will be made according to given scale.

ARTICULATION OF THE PROXIMAL EXTREMITY OF THE HUMERUS

If a dislocation of this articulation is suspected, the patient is placed in either the supine or prone position and raised on one side of the body and propped so as to get the articulation as near the plate as possible.

The exposure should be made according to the given scale.

ARTICULATION OF THE PROXIMAL EXTREMITY OF THE FEMUR

Use a plate large enough to get the articulations of both femurs (11" x 14") so as to make a comparison between them.

Place the patient in the recumbent position and center the tube directly over the plate.

When a 11" x 14" plate is used, the tube distance should be at least 24 inches so that the entire plate will be exposed. Exposure made as per the given scale.

DIRECTIONS FOR USE OF THE INTENSIFYING SCREEN

The following are directions for the use of the intensifying screen. The object of all screens is to intensify the value of the X-Rays.

As the name implies, this screen is used to intensify the value of the X-Rays, when used in connection with a

photographic plate. To facilitate manipulation, a plate holder should be used. The screen is fastened into the plate holder, emulsion side up and the photographic plate, sensitized surface down, making direct contact between the two emulsions. In this way the X-Ray must pass through the glass of the photographic plate, not as is customary in ordinary radiography.

A fine brush accompanies each screen. Always carefully dust the screen before use. It is essential that every particle of dust and other foreign material be removed from the surface of the screen and from the negative, before the plate and screen are placed in contact, otherwise the dust specks will produce pinholes in the picture by intercepting the rays from the fluorescent surface. Moreover, if any of the specks are hard and gritty they will be forced into the sensitive surface of the screen by the pressure of the springs when the cassette is closed, to remain imbedded therein forever.

X-Ray tubes of relatively low penetration should be used to show good contrasts. A high tube gives good pictures, but lacks in producing contrast.

The exposure will be reduced to at least one-fifth the usual time required to make a fully timed negative. A good contrast developer should be used.

Care must be taken to keep the surface of the screen perfectly dry. A drop of developing solution would cause mottling and a deterioration. The plate should be removed from the cassette at once after the exposure, otherwise the after fluorescence will fog the plate.

The screen should be placed in position as follows:

After the plate has been placed in the holder, as mentioned above, the coated surface of the plate and also the coated surface of the screen should be freed from all particles of dust by means of a very fine camel's hair brush. Then the screen should be placed with its coated side against the coated side of the plate. Care must be taken that at the beginning, the edges of the screen are exactly on a level with the edges of the plate, as any movements which occur later will damage the coated surface of the screen and thereby cause faulty negatives. Then the lid of the plate holder is closed. The rays thus take the following path: anti-cathode; body of patient; back of plate; coated side of the plate; coated side of the screen.

When carrying the plate holder, the screen must not be disturbed. If the plate is not developed immediately after the exposure, it must be removed immediately in every instance, as otherwise the negative will become fogged on account of the subsequent long fluorescence of the screen.

The coated side of the screen can be easily cleaned with warm water and cotton wool.

SOFT TISSUE EXPOSURES

Stomach.

These instructions should be followed closely in order to obtain satisfactory roentgenograms of the stomach. The patient must abstain from heavy foods for the dinner meal, the day previous to the exposure. A good cathartic must be taken the evening prior to the day of exposure. No breakfast should be taken.

Prior to the exposure the patient is given a solution of Barium Sulphate and buttermilk, the solution to be

thoroughly mixed by stirring continually up to the time it is taken.

Small Patient: Three ounces of Barium Sulphate in one pint of buttermilk.

Exposure, 50 milli-ampere seconds.

Back-up at 5 inches.

Exposure with the intensifying screen as follows: Use 60 milli-amperes; a 5-inch back-up; time, one-tenth of a second.

Medium Patient: Three and one-half to four ounces of Barium Sulphate in one pint of buttermilk.

Exposure, 60 to 70 milli-ampere seconds.

Back-up at 5½ inches.

Exposure with the intensifying screen as follows: Use 60 milli-amperes; a 5½-inch back-up; time, one-sixth of a second.

Heavy Patient: Five ounces of Barium Sulphate in one pint of buttermilk.

Exposure, 70 to 90 milli-ampere seconds.

Back-up at 6 inches.

Exposure with the intensifying screen as follows: Use 60 milli-amperes; a 6-inch back-up; time, one-quarter of a second.

The tube distance in all these exposures should be 24 inches and the exposure must be instantaneous.

The plate is to be taken immediately after the ingestion

of the Barium meal, with the patient in the standing position. A coin is placed on the umbilicus and the center of the plate placed over it. A 11" x 14" plate is used for this exposure. The tube is centered directly over the plate with a distance of 24 inches.

If the stomach is in its normal position, the lower border of the greater curvature will be found slightly above the coin. Hence, if a gastroptosis exists it may be easily detected.

Gall Bladder.

It is maintained by roentgenologists in general that it is absolutely impossible to obtain a roentgenogram of a normal gall bladder, for the reason that when the gall bladder and its contents are normal, there is no resistance offered to the penetration of the X-Rays and as a result, there will be no shadow reflected upon the plate. Thus, if a shadow of this viscus is reflected upon the plate it will indicate an abnormal condition.

Gall stones may be easily detected if the proper exposure is made.

The patient is prepared the same as for a stomach plate, except that there is no Barium meal given. Compression should be used with a small cone over the region of the gall bladder, with the patient lying in the prone position.

Small Patient:

Exposure, 55 milli-ampere seconds.

Back-up at 5 inches.

Medium Patient:

Exposure, 75 to 80 milli-ampere seconds.

Back-up at 5 inches.

Heavy Patient:

Exposure, 100 to 140 milli-ampere seconds.

Back-up at 5½ to 5¾ inches.

Do not overdevelop this plate as this will obliterate gall stones, if they are very small. The proper time should be given in developing. Use a tray and not a tank. A freshly-prepared developer should be used for all stomach and gall stone work.

Lungs.

The best results in lung work, as well as heart and stomach work, are obtained by using an intensifying screen. In these exposures a great deal of movement takes place and in order to obtain the desired results speed must be resorted to.

General technic seems to favor the high back-up spark of 6 inches. But if a screen is used and the time of exposure reduced as much as possible, especially in small and medium-sized patients, the tube of medium penetration will give much more detail.

The exposure in a small patient, where a 6-inch back-up

is used, will be 35 to 40 milli-ampere seconds; medium patient, 50 to 65 milli-ampere seconds; and a heavy patient, 80 to 95 milli-ampere seconds.

If a softer tube is used than one backing-up at 6 inches, the exposure can be figured accordingly. For instance, the tube in use has a back-up of 4 inches on a small patient, that would require 40 milli-ampere seconds at a 6-inch back-up. The exposure would then be 120 milli-ampere seconds, because the degree of penetration would not be so great and as a result the exposure would be longer.

In using a screen, divide the number of milli-ampere seconds required for the exposure, by one-sixth and use a heavy current to reduce the time of exposure as much as possible.

The following is an example of determining the number of milli-ampere seconds required, when a softer tube than one backing-up at 6 inches is used.

Small Patients:

The following scale is applied:

40 milli-ampere seconds at a 6-inch back-up.

80 milli-ampere seconds at a 5-inch back-up.

120 milli-ampere seconds at a 4-inch back-up.

160 milli-ampere seconds at a 3-inch back-up.

In the above scale, if the back-up is 3 inches instead of 6 inches, the exposure will be four times as long. Thus, 4x40 equals 160 milli-ampere seconds exposure at a 3-inch back-up.

Distance of the tube, from 26 to 28 inches.

Note.—Do not use less than a 4-inch back-up.

Heart.

The patient is placed in either the prone or recumbent position on the table. The prone position is preferable.

The exposure in these cases is as follows:

Small Patient:

Exposure, 40 milli-ampere seconds.

Back-up at 5 inches.

Medium Patient:

Exposure, 55 milli-ampere seconds.

Back-up at 5½ inches.

Heavy Patient:

Exposure, 65 to 75 milli-ampere seconds.

Back-up at 5½ inches.

Tube distance 24 inches.

In using the screen, reduce the time to one-sixth and use a heavy current to reduce the time of exposure as much as possible.

The tube distance should always be recorded. If a plate is taken some time later, keep the tube distance the same as in the former exposure, to note whether or not there has been a change in the size of the heart. If the tube distance changes, the size of the heart will also change on the negative.

Kidney.

The patient is placed in the recumbent position with a compression cylinder over the region of the kidney. One kidney should be taken at a time in all cases, so as to place the tube directly over it.

Small Patient:

Exposure, 120 milli-ampere seconds.

Back-up at 5 inches.

Medium Patient:

Exposure, 175 milli-ampere seconds.

Back-up at 5½ inches.

Heavy Patient:

Exposure, 250 to 275 milli-ampere seconds.

Back-up at 5½ to 6 inches.

Ureters.

The exposures are the same as those for the kidneys.

PART VI
DARK ROOM TECHNIQUE

PLATE LOADING

X-Ray plates and films must be loaded in the dark room with the ruby light no brighter than is used to develop by. If you have not a special table for loading plates, be sure that your table or shelf is absolutely clean, allowing no chemical, dirt or moisture to come in contact with either plates or envelopes. Do not load plates just after having mixed or weighed some chemicals, as the air will be laden with chemical dust which will affect the emulsion of the plates, causing fog.

To protect the plates from the actinic rays of light, it is first placed in a black envelope and then an orange one. Before starting to load your plates arrange your envelopes alternately, an orange and a black, having the flap ends all in the same direction; this will eliminate all confusion in trying to find the correct envelope in the dark.

Open the box of plates, which will be found to have two lids, after all lights are out excepting the ruby light. The first plate in the box is always placed emulsion down, after which they are arranged in pairs, held together by paper clasps at each end, with the glass surfaces together. Thus they alternate, first one glass side up, the next emulsion side up, etc., the last plate being necessarily emulsion side up.

However, never attempt to remember the order of arrangement of the plates in the box when loading. Hold

the plate to the ruby light and be sure which is the emulsion side before placing it into the envelope.

In radiograph work it is absolutely essential that you load your plates so that you will know which side carries the emulsion after it is placed into the envelope. The reason for this being that the emulsion side of the plate must always be placed next to the part to be radiographed.

The emulsion side of the plate is readily determined by holding at an angle close to the ruby light. This surface being dull gives little or no reflection, while the glass side is shiny and reflects the light. Should you not be positive by this method as to the emulsion side, moisten the index finger slightly and place on one corner of the plate. You will find that it adheres readily to the emulsion side but not to the glass surface.

Fold back the flap of the black envelope and hold in such a manner that the flap will not rub against the emulsion of the plate while slipping into the envelope. By allowing the flap to rub over the emulsion you will find upon developing that it has caused fine pencil-like lines, or brush-like scratches, called "abrasion marks." It is claimed this is due to the creation of static electricity and gives the greatest trouble in the winter months.

Hold your plate in such a manner that the glass side of the plate rests on your finger tips, the edge of the plate coming in contact with the thumb between the first and second joints. Never press the ball of the thumb or any of the finger tips on to the emulsion of the plate, as it is sure to leave the finger prints and might ruin an otherwise good plate. Slide your plate into the envelope with the emulsion side facing the smooth surface of the envelope.

Most envelopes have the seam down the center of the back; this must be next to the glass surface of the plate. Turn the flap down and insert this end first into the orange envelope. The emulsion side is still face up, so place in the orange envelope in the same manner that you did the black, emulsion side towards the smooth surface of the envelope.

By loading your plates in this manner the seam of both envelopes are on the back or glass side of the plate, and for these reasons: first, the seam on both envelopes would make four thicknesses of paper thru the center of your plate for the rays to penetrate, and should your tube be low it would show on your plate as a light streak the entire length.

Second, commercial glue, or mucilage, with which the seam is made has been found many times to contain small filings of metal; these would make pinhead spots on the finished plate.

By making it a rule to load your plates in this manner you eliminate the danger of taking radiographs thru the glass of the plates. While radiographs may be taken in this manner the glass has a tendency to cut off a part of the rays thus lessening exposure of the plates. Also in taking radiographs thru the glass side of the plates your image will be reversed and unless some form of marker is used, your readings will all be the opposite of their correct positions.

Do not load more plates than you will use in three days, as the chemicals of the paper affect the emulsion and may cause fog.

After loading, place in your lead cabinet, or at a distance of 60 to 80 feet from the X-Ray machine.

LOADING INTENSIFYING SCREEN

Great care must be taken in loading the intensifying screen to have the fluorescent surface absolutely free from all dust particles and stains. First wipe the screen with a photographer's camel's hair brush, using a light sweeping movement; then wipe the emulsion of the plate in the same way. Place the emulsion side of the plate next to the fluorescent surface of the screen and close the cassette.

In using this screen it has been observed that the quality of the plate is greatly improved when the emulsion of the plate and fluorescent surface of the screen are in contact. Therefore you will be obliged to take your radiograph thru the glass of the plate, consequently in reading be sure the emulsion is facing you and not the glass side.

The fluorescent surface of the screen should never be touched with the hands. Should it become dirty and stained so that simple brushing with the camel's hair brush will not remove it, clean in the following manner; moisten a tuft of cotton with grain alcohol and wipe gently, or for stains use a solution of best grade of hydrogen peroxide. Be sure that the surface is thoroughly dry before placing your plate in position.

The finished plates will present many minute pinholes, which defects are due to the small particles of calcium tungstate of which the screen is made. It is an easy matter to distinguish a screen plate by this characteristic. Remove the plate as soon as the exposure is made, because the prolonged fluorescence of the screen will cause the plate to fog. If it is not to be developed immediately, place in the regular envelope and store in the lead cabinet.

Develop in the usual manner.

Never store your intensifying screen in the dark room, where there are any chemicals or acid fumes; keep in a dry cool place, preferably the lead cabinet.

DEVELOPING

The process of developing finishes the chemical action which was started as soon as the rays struck the plate. It is essentially a chemical process and consists in oxidizing the silver salts contained in the emulsion. Only that part of the emulsion struck by the rays will become oxidized in the developer, the remainder will not be changed but remains a lemon-yellow until dissolved by the hypo fixing bath.

Use only chemicals of a standard quality; have clean trays and an absolutely safe ruby light. These are paramount factors in producing the best radiographs.

Mix your developer by using equal parts of solutions A and B of the formula given later, having the temperature between 65 and 70 degrees. About ten ounces for an 8x10 tray is the most convenient amount; less would not cover your plate sufficiently while more would make it slop as the tray is rocked.

Remove your plate from the envelope, using the same care you did in loading. Turn the flap of the black envelope back so that it will not rub the emulsion as it slides out. Hold the plate, emulsion side up and allow it to slip on to the finger tips, catching the edge between the first and second joints of the thumb. Keep the fingers off the emulsion surface.

Slip your plate into the tray of the developer quickly, emulsion face up, and shake the tray vigorously to be sure that it is evenly covered and to remove all air bells. Air bells, or bubbles, must be dislodged within the first thirty seconds the plate is in the developer or they will remain throughout the process and be visible on the finished plate as round transparent spots and pinholes. Rock the tray gently throughout the development to keep any sediment from settling into the emulsion and also to expedite the process.

The time for development will depend upon the exposure of the plate and the temperature of the developer. For the finest chemical results the temperature of the developer should be 65 degrees. Warmer developer softens the emulsion, making it very sticky, and develops the plate too rapidly, which is likely to cause them to be streaked and uneven. A lower temperature allows it to develop too slowly, permitting of chemical fog.

The density of the negative will increase as the time of the development is prolonged up to the point where the emulsion is oxidized entirely thru to the glass of the plate. By occasionally lifting the plate out of the developer and looking at the back you will be able to see to what extent it is developing. When it is entirely developed the plate will look the same on both sides.

When you carry development beyond this point chemical fog will set in and will be noticeable by the yellow emulsion, up in the corner where the marker is placed, turning a gray, smoky color. Further development will only deaden the contrast of the lines and make your plate harder to read.

A ten-ounce tray of developer should not be used for more than six to ten plates.

RINSING

Remove the plate from the developer and rinse for half a minute in clean cold water. Should you place your plate directly in the hypo, or fixing bath, without first rinsing you are very likely to cause minute blisters over the entire surface, thus making an unsightly plate and one very difficult to read. This is because the developer is alkaline in reaction and causes a violent chemical reaction with the fixing bath, which is strongly acid.

FIXING

After your plate has been in the fixing bath for three minutes it will be safe to turn on your white light.

Your plate should be clear, that is, all the yellow of the emulsion removed within five minutes after placing in the fixing solution. Allow your plate to remain in the fixing bath for at least five minutes after it is cleared, for while it looks transparent the unoxidized silver will not all be dissolved out. Therefore, ten minutes is the minimum length of time they should be left in the hypo bath, fifteen to twenty minutes is absolute safe, and longer will not hurt. By leaving them in your fixing bath several hours a slight reduction takes place which reduces the density of the plate.

WASHING

Plates are more easily and quickly washed by using running water. Do not allow the force of the water from

the tap to fall directly on the plate, as it invariably raises the emulsion. A regular plate washer can be attached to the tap, but a rubber tube is preferable. Allow the plates to wash fifteen minutes in running water, or, if running water is not available, wash in ten complete changes of water, consuming thirty minutes in all. Should the tap water be riley, put on a filtering cap, as any sediment in the water will settle in the emulsion of the plate.

DRYING

Great care should be taken in properly drying the negative, as often a good plate is spoiled by careless drying. They are best dried in a room of normal temperature which is free from dust. Do not attempt to dry quickly by placing in a warm place or in the sun, as the emulsion will melt and run off the plate. Place on a drying rack and not too close together, as they are likely to dry unevenly and slowly, which may leave drying marks.

Removing from one room to another of different temperature after a plate is partially dried will vary the density of the part which dried last. This causes large circular spots.

In cold weather do not leave where the moisture will freeze on the plate before it is dry, as this will give a mottled appearance.

Should you wish to dry the plates quickly, place them before an electric fan. The harder the gelatine (the emulsion) is fixed on the plate, the quicker it will dry. The emulsion can be hardened to a greater extent by placing the plate, after it is all fixed and washed, in a five per cent solution of formaldehyde for five minutes. Another method of

quick drying is to moisten a tuft of cotton with grain alcohol and gently swab over the surface of the plate and then place before the fan. If you use the latter method be sure all hypo is washed out of the plate.

DEVELOPING X-RAY FILMS

As the new X-Ray films recently perfected by the Eastman Kodak Company are duplitized (that is, coated on both sides), it is not necessary to look for the emulsion side either in loading or developing. If developed in the tray care must be taken not to scratch them and use a little more developer in the tray than you would for plates so as to allow them to float as much as possible.

We have found in using these films that a standard time developer is the best, as it is otherwise very hard to judge when they are finished. The time for development is reduced about twenty-five per cent over that of the X-Ray plate, because the same amount of emulsion is spread over both sides of the plate instead of upon one, therefore making it thinner and allowing the developer to penetrate more rapidly. In using the developer formula herein given, it will require about three and a half minutes to develop a normally exposed X-Ray film.

The developing tanks and loaders advised to be used with duplitized X-Ray films will appeal to the busy Roentgenologist. They minimize the work, are absolutely reliable and give uniform results.

The many advantages of films over plates will readily appeal to you but we must impress upon you the extreme caution necessary in handling while loading and developing.

DEVELOPING DENTAL FILMS

Dental X-Ray films are prepared with two films in each capsule, or envelope, one intended for the patient and the other for the dentist. They are to be developed in the regular manner until the object appears the same on both sides. Wash and fix as usual.

If some identification mark is needed to distinguish different films, a very simple method is to use a soft lead pencil mark on the emulsion side of the film before it is developed. Mark close to the edge on the narrow ends to avoid interfering with the important part of the film.

A developing tank for dental films is a great advantage if you are doing considerable of this kind of work. The regular dental developing tank as supplied by The E. K. Co., will hold eight pairs of films at a time. Your assistant can handle the work with this method very readily, as it converts it into a mechanical operation.

DEVELOPER FORMULA

Solution A—	Water, preferably distilled..	1	gal.
	Metol or substitute........	¼	oz.
	Hydroquinone	4	oz.
	Sodium Sulphite	7½	oz.
Solution B—	Water	1	gal.
	Sodium Sulphite	7½	oz.
	Sodium Carbonate	10	oz.
	Potassium Carbonate.......	5	oz.
	Potassium Bromide	¾	oz.

By warming the water, not to exceed 120 degrees it is much easier to dissolve the chemicals; see that each is

added in the order given and also that each is thoroughly dissolved before adding the next.

This formula has been found to give the maximum of results in our laboratory work, and we can recommend it to you. When the solutions are kept separately this formula will keep a considerable time.

Use equal parts of solutions A and B: do not mix until ready to use. The temperature should range from 65 to 70 degrees while using. For the normal exposure it will require about four minutes to develop.

FIXING BATH OR HYPO

Because of the heavy emulsion on X-Ray plates we have found that the chrome alum bath is the best adapted for our work, as it hardens the gelatine to a greater degree than the most commonly used acetic acid hardener. Nevertheless, hypo fixing salts, which you can buy at any photo-supply dealer, will answer the purpose. Simply dissolve them in the given quantity of water.

The acid fixing bath does two things in fixing the plate; first, the hypo-sulphite of soda dissolves the unoxidized silver bromide from the emulsion, making it a soluble salt of silver and rendering the plate transparent. A plate is only one-half fixed when the yellow milky color disappears. To remove plate then and wash and dry it will give rise to stains later. Secondly, the chrome alum of the bath hardens the gelatine emulsion, making it firm and adhesive to the plate. When the emulsion is hard and set it will dry more quickly and is less liable to be scratched.

Hypo bath is cheaper than ruined plates. Keep your bath fresh and clean to obtain best radiographs. Do not add new hypo bath to one partly used.

When the hypo fixing bath will not clear the plates in five minutes throw it out and make up new. When not in use, keep your fixing bath covered to keep out dirt and prevent evaporation.

HYPO FIXING BATH FORMULA

Solution A—	Crystal hypo	4 lbs.
	Water	120 oz.
Solution B—	Chrome alum	4 oz.
	Sodium sulphite (dried)	8 oz.
	Water	60 oz.
Solution C—	Sulphuric acid C. P.	½ oz.
	Water	20 oz.

Mix each sub-division separately, then add C to B and thoroughly mix before adding to A. Have C and B cold before mixing. Any photo supply dealer can prepare this formula for you if you have not your own chemicals.

INTENSIFICATION

By this method it is possible to build up a thin, underdeveloped plate to a great degree, and an underexposed plate to a point where it is possible to make a reading. The under developed plate will show a very marked improvement, while the underexposed plate not quite so much, but in a great majority of cases you can save yourself the ex-

pense, time and inconvenience of making the radiograph over.

This is a chemical process that will increase the density of the silver oxide in the emulsion and make the lines of demarcation more visible. Before the process is begun, however, it is imperative that all traces of hypo be washed out of the plate. Wash for an additional fifteen or thirty minutes and while your emulsion is still wet place in solution A.

Solution A is known as the bleacher and your plate should be left in it until the image all but disappears and a heavy white coating is formed on the emulsion. The operation may take from five to fifteen minutes. Rock the tray continually during the operation. When finished, rinse thoroughly and place in solution B.

When placed in this solution the image will gradually blacken and should be left here until it is of an even color all over. This should not require more than five minutes.

Examination before the light will now reveal a greater density than the original negative, making it now possible to see the lines of demarcation. After intensification, the negative must again be thoroughly washed before drying.

It is understood, of course, that intensification should only be used when you have a noticeable image to begin with as a base. This entire process is performed under a white light.

INTENSIFIER FORMULA

Solution A—Bi-chloride of mercury.......120 gr.
Potassium bromide ....120 gr.
Water .... 16 oz.

Solution B—Sodium sulphite .... 2 oz.
Water .... 16 oz.

Keep in dark bottles; mark solution "poison."

To use:—Bleach with solution A. Rinse and place in solution B to blacken.

REDUCTION

An over-exposed plate which is so dense that it cannot be read may in the majority of cases be reduced by this method so that it is readable.

First, be sure that all hypo is washed out of the plate by giving it an extra washing of fifteen to thirty minutes. Place in the tray of solution while the emulsion is still wet. Keep the tray rocking until the reduction is sufficient to enable you to make a reading. The time will vary according to the density of the plate and the amount of reduction desired, usually requiring five to twenty minutes.

If only a local reduction is desired after the plate is thoroughly washed apply the solution repeatedly with a tuft of cotton to that part only.

When this operation is completed it will be necessary to wash the plate again for about thirty minutes in order to remove all chemicals and insure safe keeping.

The formula given below is similar to that which you may buy put up in sealed tubes from any photo supply dealer.

In making up this formula, if the two solutions A and B are kept separately and in dark bottles, there will be no

appreciable deterioration. This is not true, however, after they are mixed ready to use.

REDUCER FORMULA

Solution A—Potassium ferricyanide	....	1 oz.
Water	....	16 oz.
Solution B—Crystal hypo	....	1 oz.
Water	....	16 oz.

To use, mix one ounce of Solution A with eight ounces of Solution B. This operation is performed under a white light. Wash the tray well after finishing, using a little Sapolio to scour.

STORAGE OF PLATES AND MATERIALS

X-Ray plates must be kept in a cool, dry place with the boxes on edge and not lying flat. Do not store near radiators or steam pipes; you will have defective plates if you do. Dampness or any form of moisture is equally bad for plates. Do not have them in a room where there is gas burning for any length of time, or near new paint, or the vapor of turpentine. We cannot impress on you too strongly the extreme sensitiveness of the plates as to both light and chemicals. Plates kept on edge and in a cool dry place will keep for a year without deterioration.

As the X-Rays will penetrate a distance from 60 to 80 feet from the tube, plates must either be kept at a greater distance than this or in a lead lined cabinet. The ordinary wall is no protection to the plates when the tube is being used, as X-Ray plates can be fogged through several walls.

All chemicals must be kept in tight containers, as they absorb moisture from the air, which causes deterioration. Ready prepared formulas come in waxed paper or glass containers so that they will keep under any ordinary conditions.

DARK ROOM EQUIPMENT

The room to be used as a dark room should be located where running water is accessible and where good ventilation is permissible. The size of the room needed will depend somewhat upon the amount of work handled. For the average Chiropractor I should say a room 6x8 would suffice. It must be absolutely dark, not allowing the faintest trace of light to enter thru cracks, pinholes or around curtains. The least conceivable ray of light will, if allowed to strike a plate, cause fog. I have seen dark rooms which were not more than 6 feet square built inside the X-Ray operating room, artistically finished on the outside and lined with black building paper on the interior. These proved to be practical and convenient.

It should be arranged to have one table for developing, one for plate loading and one for the fixing bath; have the fixing bath nearest the sink. Do not have any unnecessary shelves or tables, as the dark room is a place where rubbish will accumulate very rapidly. It should at all times present the same tidy appearance as your other offices. When you work in here, you do so as a chemist, for all the dark-room operations are but chemical processes. The chemist never allows dirt to accumulate; never uses dirty utensils; never allows any spilled chemicals to remain on tables, scales or floor. You must do the same.

Probably the most important part of your dark-room equipment is the ruby light. As a majority of ruby lights are not safe, be positive that you have a safe one and you may test it in this manner: Place an unexposed plate under the light (emulsion up) the same distance that you would do your developing; lay a coin or piece of metal on it, and leave exposed for five minutes. Now, develop the plate and if any outline of the object shows on the finished plate your light is unsafe.

Never use any metal containers for mixing your solutions; use a glass graduate or bottle. Steel enameled trays are the most durable of all, while glass or fiber are as suitable. Four trays should be the correct equipment for your work. You should have two graduates, a 32 oz. and a smaller one; a hard rubber stirring rod and dark colored bottles with stoppers to keep the solutions in.

Many forms of developing tanks are on the market and any of the standard quality are suitable if you desire to use this method. Entirely satisfactory results may be obtained with the tank method providing the temperature can be controlled. Our only advice, however, about this method would be to use a metol-hydroquinone developing formula. It has been our experience in the P. S. C. laboratory that the shadows and finer details of spine work are best shown by the above developer, while pyro developer is very contrasty and oxidizes quickly.

The most convenient method for taking care of your fixing bath is to obtain a regular fiber fixing box made for that purpose. Your solution can be kept until used up if covered when not in use.

A plate washer in which the plates can stand on edge and the water allowed to flow thru them will wash your plates quickly and easily and occupies very little space.

A drying rack will enable you to dry your plates more quickly and evenly and it should be up away from any dust. As these are inexpensive you cannot afford to be without one.

Photo supply dealers are now selling a fibroid cloth, black in color and similar in appearance to oil cloth. This is intended for covering tables, trays and making aprons. It is acid and alkali proof and is an excellent article for these purposes.

DARK ROOM "DONT'S"

1. Don't give your plates to a photographer to develop unless he has had special instructions in developing X-Ray plates, for he will be guided by the method used in ordinary photographic developing and your plates will be under-developed.

2. Don't use old, weak developer, for its cost is nothing compared with the cost of a plate. The developer commences to oxidize as soon as it is mixed and unless kept on ice or in a very cool place, will not keep over from one day to the next.

3. Don't rub your fingers over the surface of the plate while it is developing.

4. Don't put the hands into the hypo and then back into the developer, for a few drops of hypo solution in the

developer will absolutely ruin it. Wash the hands well and then dry.

5. Dont use a tray for hypo one day and for developer the next. Mark your trays and use them for the same solution each time.

6. Don't strengthen old weak hypo with some new. Throw it out and make another batch.

7. Don't turn on your white light until the plates have been in the fixing bath for at least three minutes.

8. Don't remove the plates from the fixing bath to wash for at least five minutes after they become clear.

9. Don't hold your plate to a bright light for examination until the hypo bath has removed all milky appearance.

10. Don't load plates just after mixing or weighing chemicals in your dark room.

PLATE TROUBLES

Ninety-nine per cent of plate defects are due directly to careless manipulation in the dark room.

Fog, a smoky appearance; due to unsafe ruby light, too long in the developer, the plates not being properly stored, or chemical dust while loading.

Flat negatives, having little or no contrast, may be due to any of the following: under-exposure, cold developer, under-development, or exhausted developer.

Pinholes, or round, transparent spots, are due to air bells. These form the second the plate is put into the de-

veloper and may only be overcome by vigorously shaking or rocking the trays. These occur more frequently in the tank method.

Hypo or other chemical rust, may settle on the plate during loading and cause either transparent or dark spots.

Small dark spots are usually caused by using envelopes on which some developer has been spilled or by water spattering on the plates before developing.

Streaky plates may be caused by improper, uneven drying, by rocking the tray in one direction only during development, or a hypo solution that is old and exhausted.

Stains—milky streaks may be due to inusufficient washing wherein all hypo is not removed; this usually appears two or three days after being dried.

Yellow stains usually due to old developer, or pyro developer.

Greenish stains due to too warm a developer.

Bluish, almost metallic luster, prolonged over-development causing a deposit of metallic silver.

Abrasion marks, caused by rubbing the surface of the plate while loading or careless handling afterwards.

CONCLUSION

In conclusion, I wish to impress on the student or practitioner that in studying this text, or taking the course as taught by this institution, that it is our aim to give the student a foundation of Chiropractic spinography, which he can improve upon only by experience.

After all that has been written upon the subject of Roentgenology,there is still more that could be written, as the possibilities of the X-Ray are far-reaching, and unknown today, as every year sees improvement and development of this great work.

Therefore, it is the hope of the author that this text will be of assistance to every one who reads it and that they will become a student of this work, not only today, but tomorrow and every other day. Who knows but what you may develop some unknown X-Ray technic?

It is to be expected that you may spoil plates when commencing to use spinography in your practice, which will teach you your weak points so that your next exposure may be improved upon. Experience is the best teacher after all.

If this work has been beneficial to the Chiropractic field it is intended for, even tho there are some who do not use it in their practice, it will have served its purpose.

THE END.

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Spirograph Developing

Chromo Alum Hardner

When wash water is above 75°

— Formula —

Chrome Alum 1#

Water pure 1 gal

Place film or plate into this solution immediately after removal from the developer, and allow to remain 3 to 5 minutes, then place in the hypo bath, and proceed in the usual manner.

E. A. Thompson